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# Performance Evaluation of a Mechanical Potato Seed Cutting Machine

Mumtaz Ahmad, Muhammad Younis and Imtiaz Saeed
Department of farm Machinery and Power
University of Agriculture, Faisalabad-38040, Pakistan

## bstract

the present study a mechanical potato seed cutting machine developed in the Faculty of Agricultural Engineering and echnology, University of Agriculture, Faisalabad was evaluated for its performance. The study revealed that the newly eveloped machine could be successfully used for potato seed cutting. Minor modifications have been suggested for provement of the operation. The main objectives of the study were to compare the performance of potato seed cutter th traditional system and identify problems associated with the machine. The mechanical system of cutting potato seed as found more economical and time saving as compared to manual cutting. However, tuber feeding and collecting ocesses need to be made automatic and uncovered moving parts need covers. Keeping in view the non-availability of ectricity at most of the Pakistani farms, replacement of electric motor with the same horse power internal combustion gine is suggested. The out put of the machine varied from 430 to 466 kilograms per hour.

## troduction

tato plays a significant role in human diet as a pplement to wheat and rice and it has been found to oduce more food per unit area than the cereals haudhry, 1988). The present per hectare yield of 11.4 nes is considerably low against 25-40 tonnes obtained the major potato growing countries (Akhtar, 1987). Most the potato growers in Pakistan are using much higher ed rate (3.5 ton $ha^{-1}$) compared with recommended antity of 2 ton $ha^{-1}$ (Akhtar, 1987). Cost of production exorbitantly high as one would require seven to nine usand rupees for the production of one acre of potato. e major items contributing to this high cost are the price seed and labour for cutting seed into pieces. The nventional method of cutting potato seed is to cut it nually into pieces in order to multiply seed and sequently reduce the cost of seed per unit area. It uld be noted that each cut piece should have at least or three nodes. However, seed cutting is much urious operation in potato production. The scarcity of ur has been a problem during the last decade because arm labour migration to industrialized cities and foreign ntries and therefore, the need for mechanized potato d cutting is seriously felt. Lipskil *et al.* (1992) worked on design of an automated unit for cutting of potato seed. ers are conveyed through a cleaner into a sorter, where atoes under 80 g weight were separated from the larger ers (80-140 g) which were cut and treated by ective chemicals prior to transport into hoppers ready sowing. The unit had an output of 6 t/h.

ping this situation in view, a mechanical potato seed er was developed at the Faculty of Agricultural neering and Technology, University of Agriculture, alabad by Shafi (1990). However, a comprehensive uation of the mechanical potato seed cutter was led. Therefore, it was considered imperative to evaluate performance of the seed cutting machine. The main ctives of the study were to compare the performance of potato seed cutter with traditional system and to identify problems associated with the machine.

## Materials and Methods

This study was planned to evaluate performance of a locally made potato seed cutting machine (Fig. 1). The machine is powered through 0.5 h.p., 1450 rpm single phase electric motor. For reducing the speed of motor from 1450 to 9 rpm at the shaft S, two steps are involved. Firstly using pulleys P1 and P2 and secondly worm and worm gear mechanism (WandW). The drive plate P is fixed with the center shaft S. The cylindrical cam C is fixed with the Table T. The shaft S can freely rotate in the cam. Equally spaced square rods, called plungers G are used. When the center shaft rotates the driving plate also moves carrying all the plungers. Owing to cam action, the rotary motion of plungers and their up and down motion occurs simultaneously. The plates L and J are provided to avoid twisting of plunger rods in horizontal plane. The plate E is the main activity plate with eight holes, each hole having a pocket attached underneath. At the lower end of the pocket, two sharp blades at 90° to each other are fixed. The cut potatoes are discharged through the lower ends of the pockets, when plunger is at the bottom dead center position.

Rectangular pipe frame T is used to hold the center shaft. The table is strong enough to avoid unnecessary vibration. The important machine systems are discussed below:

**Power Transmission System:** Power is supplied by 0.5 h.p. electric motor having 1450 rpm. This speed is reduced in two steps. Firstly, the smaller pulley P1having dia 2.75 inches and other pulley P2 having 10 inches dia. The larger dia. pulley P2 is attached horizontally with a worm and placed in two universal bearings. The horizontal motion is transferred to vertical motion with worm and worm gear assembly. A 1.5 inch center shaft transmits power from the motor to the drive plate carrying all plungers. The shaft is embedded in a thrust bearing at the lower end and is

supported by a foot step bearing at the upper end halted on the plate of table.

**Feeding System:** The potato tubers are manually fed into pockets at a point where plunger is at the top dead center position. As the center shaft moves at 9 rpm with eight plungers, the number of potatoes to be fed manually stand 72 per minute. The top of the table is used as a feeding platform.

**Cutting System:** The cutter plate is the main activity plate with eight holes, Each hole having a pocket attached underneath. At the lower end of the pocket two sharp blades at 90 degrees to each other are fixed. The cut pieces are discharged through the lower end of the pockets after being cut by the blades when plunger is at the bottom dead center position. That is how potato tubers are cut into four pieces

**Delivery System:** The potatoes cut into pieces during operation are delivered under the bottom dead center position of plungers.

**Laboratory Tests for Seed Damage:** The Dutch potato varieties BEDALIN 1990, KONDOR 1991, and ROMANO 1991 were fed manually into each pocket of the potato cutting machine and the cut pieces discharged through the lower end of the pockets were collected. In this way, a single potato tuber was cut into almost four equal size pieces. The surfaces of cut pieces that resulted from the machine operation were observed under the microscope and visual inspection for fine cracks, moderate damage and seriously damage of the cut pieces were recorded.
The half of the potato seeds were cut manually with a sharp knife. The cut pieces were weighed individually for uniformity of seed pieces. The potato seed damage during manual/machine cutting was calculated from the following formula:

$$Sd = \frac{T_s - D_s}{T_s} \times 100$$

where,

Sd = Seed damage (%)
Ts = Total seed pieces
Ds = Damaged pieces

**Field Evaluation of the Cut Potato Seed:** Field study was conducted in the research area of the Department of Irrigation and Drainage, University of Agriculture, Faisalabad. After cutting operation, the seed pieces were planted on ridges 70 cm apart and plant to plant distance was maintained at 20 cm. Experimental plot measured 13 m x 5 m. The cut potato pieces were used as seeds and were buried under soil to a depth of 7.0 cm. Irrigation water was applied immediately after planting. However, the following crop data were collected to access the performance of potato seeds.

**Plant Emergence Percentage:** Total emergence percentage of the plants were calculated after eight days of sowing and then at a three days interval up to the completion of germination.

**Plant Height:** Height of the plant is a very important parameter for assessing plant growth. Five plants were selected randomly from each of the row to calculate the average height of the plants.

**Yield Comparison of Machine vs Manual:** The total yield of the potatoes per plot were weighed in order to compare the yield.

**Cost Analysis:** The first requirement of a machine is to perform the intended function satisfactorily, however economic aspect of the machine plays a vital role in its acceptability by the end users. The cost analyses of mechanical and manual operations were made to determine economic viability.

## Results and Discussion

**Testing of the Machine:** The potato seed cutting machine was tested for quantitative as well as qualitative performance. The tests conducted and the results are discussed in the following sections:

**Speed of Operation:** The designed speed of the main shaft was 9 revolutions per minute. It was considered necessary to check the speed of the shaft practically as its speed determines the output of the machine. The speed of shaft was found 8.5 rpm with loose belt and this speed increased to 8.75 rpm on tightening the belt. Manual feeding of potato could be comfortably done at this speed. The increase in the speed was, no doubt, useful in increasing machine capacity, however, the disadvantage of more crushing than pure cutting was apparent in addition to the possibility of accident.

**Working Capacity of the Machine:** The output capacity (weight of cut pieces discharged per unit time) is important feature of a machine. In order to determine output capacity of the machine, it was operated for complete revolutions by feeding potato tubers in each pocket and the output of cut pieces at the discharge was weighed. This was repeated ten times. As the machine is moving at a speed of 8.75 rpm totally into 525 revolutions per hour, the discharge at the end of each three revolutions was multiplied with 175 to provide the output of the machine in kg $h^{-1}$.
The mean output of the machine was approximately [illegible] $h^{-1}$ with a standard deviation of 11.68. It [illegible]

Table 1: Working capacity of the machine

| S.No. | Weight of potato pieces after 3 revolutions (kg) | Capacity (wt. of potato pieces per hour (kg) |
|---|---|---|
| 1 | 2.619 | 458 |
| 2 | 2.500 | 438 |
| 3 | 2.521 | 441 |
| 4 | 2.660 | 466 |
| 5 | 2.625 | 459 |
| 6 | 2.486 | 435 |
| 7 | 2.555 | 447 |
| 8 | 2.457 | 430 |
| 9 | 2.625 | 459 |
| 10 | 2.603 | 456 |
| Mean | | 448.9 |
| S.D. | | 11.68 |

ieneralized that the capacity varied from 430 to 466 kg $h^{-1}$ pproximately (Table 1). It was concluded that the larger ariation in the capacity of machine has resulted from ariation in the size of potato tubers, whereas, number of eeds cut per unit time do not vary extensively.

**Comparative Performance of the Machine with Manual Cutting Operation:** The qualitative performance of the nachine compared with manual cutting of potato seeds vas evaluated to make comparisons between the two nodes of cutting.

**Variation in the Sizes of Cut Tubers:** In order to properly onceive the variation in machine capacity, size distribution f tubers was studied. Potatoes were randomly picked from ach lot, weighed and their volumes determined in a graduated cylinder having water. The data are given in Table 2.

It is obvious from standard deviation (11.68) that the variation in size of tubers is considerable. A wide variation in size of the potatoes explains the variation in machine capacity.

The variation in machine capacity was also due to the single sized pockets which may not be desirable to accommodate all sizes of potatoes.

**Uniformity of Seed Pieces:** Twenty pieces of cut seeds were randomly picked from each lot cut by machine and manual operations. All the pieces were weighed individually (Table 3) and unpaired t-test was employed to test statistical significance of the two means. The results revealed that the difference between the means was non significant clearly suggesting that the machine and manual cutting operation were similar as regards to the uniformity of operation, that is the distribution of sizes of cut pieces is the same, both in machine and manual cutting.

**Laboratory test for seed Damage:** The potato seed pieces resulting from machine and manual cutting were compared by visual inspection in the laboratory. Seeds without damage, with minor injuries/cracks and with major injuries/cracks were designated as undamaged, moderately and seriously damaged respectively. Among the 60 pieces observed resulting from machine cutting, three were moderately injured, no one containing severe damage was located. This indicates 5 percent seed damage. This loss is still higher than expected one. It may be kept in view that the moderately damaged seeds have good probability of being viable.

In case of manually cut pieces only two were found to be under moderate damage and no one was observed to be

able 2: Variation in the sizes of cut tubers

| .No. | Weight of the tuber | | | Volume of the tuber | | |
|---|---|---|---|---|---|---|
| | Varieties | | | | | |
| | Bedalin | Romano | Kondor | Bedalin | Romano | Kondor |
| | 96.10 | 92.00 | 77.00 | 88.00 | 89.00 | 71.00 |
| | 72.00 | 97.00 | 82.00 | 70.00 | 92.00 | 78.00 |
| | 99.00 | 89.00 | 68.50 | 94.00 | 85.00 | 65.00 |
| | 97.00 | 97.50 | 78.00 | 91.00 | 94.00 | 77.00 |
| | 91.00 | 99.00 | 77.50 | 90.00 | 98.00 | 74.00 |
| | 73.00 | 83.50 | 84.00 | 68.00 | 78.00 | 80.00 |
| | 79.00 | 91.00 | 76.00 | 75.00 | 86.00 | 71.00 |
| | 84.50 | 80.50 | 70.50 | 80.00 | 83.00 | 65.00 |
| | 82.40 | 89.00 | 69.50 | 80.00 | 83.00 | 65.00 |
| 0 | 102.00 | 100.00 | 74.50 | 97.00 | 95.00 | 70.00 |
| 1 | 90.00 | 84.00 | 80.00 | 84.00 | 84.00 | 80.00 |
| 2 | 99.50 | 90.00 | 70.00 | 70.00 | 85.00 | 70.00 |
| 3 | 77.00 | 94.50 | 72.00 | 81.00 | 90.68 | 68.00 |
| 4 | 85.00 | 98.00 | 78.50 | 86.00 | 95.00 | 72.00 |
| 5 | 90.00 | 92.00 | 81.00 | 79.00 | 91.00 | 80.00 |
| ean | 87.87 | 91.80 | 75.93 | 82.20 | 87.93 | 68.47 |
| D. | 9.49 | 6.99 | 5.25 | 8.64 | 6.33 | 5.02 |

Table 3: Uniformity of cutting seed pieces

| S.No. | wt. of mechanically cut pieces | | | Wt. of manually cut piece | | |
|---|---|---|---|---|---|---|
| | Varieties | | | | | |
| | Bedalin | Romano | Kondor | Bedalin | Romano | Kondor |
| 1 | 35.50 | 14.50 | 34.00 | 20.50 | 18.50 | 24.00 |
| 2 | 25.00 | 19.00 | 22.50 | 17.00 | 19.10 | 22.00 |
| 3 | 31.20 | 16.10 | 19.50 | 23.50 | 22.00 | 18.00 |
| 4 | 19.00 | 22.00 | 12.00 | 29.00 | 11.50 | 19.00 |
| 5 | 18.00 | 21.50 | 21.40 | 16.00 | 17.50 | 27.00 |
| 6 | 17.80 | 17.00 | 18.00 | 21.50 | 15.00 | 20.40 |
| 7 | 27.00 | 25.00 | 30.00 | 19.00 | 13.00 | 20.10 |
| 8 | 18.00 | 12.50 | 29.50 | 22.40 | 21.50 | 32.00 |
| 9 | 12.00 | 18.50 | 25.00 | 15.00 | 12.00 | 27.00 |
| 10 | 13.00 | 15.00 | 17.50 | 22.00 | 14.00 | 19.00 |
| 11 | 20.00 | 20.20 | 13.00 | 19.50 | 18.00 | 22.00 |
| 12 | 21.50 | 9.00 | 26.50 | 23.00 | 20.00 | 13.50 |
| 13 | 2.20 | 16.00 | 14.00 | 22.50 | 17.50 | 11.00 |
| 14 | 26.10 | 14.50 | 11.00 | 20.00 | 13.00 | 16.00 |
| 15 | 13.00 | 15.00 | 19.00 | 27.00 | 19.50 | 22.50 |
| 16 | 20.00 | 23.50 | 27.00 | 15.50 | 21.00 | 26.00 |
| 17 | 24.50 | 20.00 | 9.50 | 18.50 | 12.50 | 20.00 |
| 18 | 16.00 | 18.00 | 17.00 | 17.00 | 15.00 | 19.50 |
| 19 | 15.00 | 11.00 | 14.00 | 20.00 | 9.00 | 17.00 |
| 20 | 10.00 | 13.00 | 17.00 | 18.00 | 13.00 | 15.00 |
| Mean | 20.39 | 17.07 | 19.03 | 20.27 | 16.13 | 20.05 |
| S.D. | 6.48 | 4.07 | 6.67 | 6.63 | 3.70 | 6.62 |

Table 4: Damage test for mechanically cut pieces. (Lab. Test)

| S.No. | Undamaged | | | Moderately Damaged | | | Seriously Damaged | | |
|---|---|---|---|---|---|---|---|---|---|
| | Varieties | | | | | | | | |
| 1 | Bed. | Rom. | Kon. | Bed. | Rom. | Kon. | Bed. | Rom | kon. |
| 2 | Yes | Yes | Yes | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | Yes | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | Yes | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | | | | | | | | | |
| 16 | | | | | | | | | |
| 17 | | | | | | | | | |
| 18 | | | | | | | | | |
| 19 | | | | Yes | | | | | |
| 20 | | | | | | | | | |

Bed. Stands for Bedlin  Rom. Stands for Romano  Kon. Stands for Kondor

seriously damaged. This indicates 3.3 percent seed damage and these losses, both in machine as well as manual cutting, are chance occurrences. The results are presented in Table 4 and Table 5.

**Plant Emergence Percentage:** In order to compare the viability of tubers cut by machine and manual labour seeds were planted in a planned experiment. To record plant emergence, plants emerged in a row six meter were counted from each plot sown by using mechan and manually cut seeds.

Plant emergence percentage depends upon the ra

Table 5: Damage test for mechanically cut pieces. (Lab. Test)

| .No. | Undamaged | | | Moderately Damaged | | | Seriously Damaged | | |
|---|---|---|---|---|---|---|---|---|---|
| | Varieties | | | | | | | | |
| | Bed. | Rom. | Kon. | Bed. | Rom. | Kon. | Bed. | Rom | kon. |
| | Yes | Yes | Yes | | | | | | |
| | | | | | Yes | | | | |
| 0 | | | | | | Yes | | | |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | Yes | | | | | |
| 0 | | | | | | | | | |

ed. Stands for Bedlin Rom. Stands for Romano Kon. Stands for Kondor

able 6: Analysis of variance for crop yield per plot

| ource | Degree of freedom | Sum of Squares | Mean Squares | Prob. |
|---|---|---|---|---|
| plication | 2 | 0.006 | 0.003 | 0.0481 |
| arieties (V) | 2 | 0.020 | 0.010 | 4.1544 |
| ror-I | 4 | 0.263 | 0.066 | |
| tting (C) | 1 | 0.228 | 1.228 | 0.0558 |
| X C | 2 | 0.011 | 0.005 | 0.4496 |
| ror-II | 6 | 0.072 | 0.012 | |
| tal | 17 | 0.600 | | |

tablished plants and seeds planted. Ratio of established ants to seeds sown is usually fairly low. This may be due the factors related to poor soil pulverization, shortage of ater and damage or loss by insects etc. Therefore, ratio of tablished plants is very important for users of machine to timate the amount of seed actually required and for gineers to evaluate the seeding operation. A graphical mparison of total plant germination is shown in Fig. 2. umber of plants emerged were counted and the seeds not rminating and emerging from the soil were calculated in ch row by the following formula:

$$P = \frac{G}{(N+G)} \times 100$$

here,

= ratio of established plants.
= number of non-emerged seeds in each row.
= number of established plants in each row .

The effect of cutting technique on plants germination was thus observed. For assessing the comparative performance of the two techniques, data were analyzed statistically. It was observed that due to difference in cutting operation, the main effects of cutting techniques as well as interactions were statistically significant at 5 percent level of probability. It was also indicated that mechanical cutting is more economical, time saving and less laborious than manual cutting.

**Total Yield of the Crop:** Total yield of the crop was considered for comparative performance of the two techniques. The result of analysis of variance is given in Table 6. It is evident from the table that the main effect is statistically nonsignificant at 5 percent level of probability. However, comparative performance of the mechanically cutting technique gave equal or the best yield of crop over traditional technique of seed cutting.

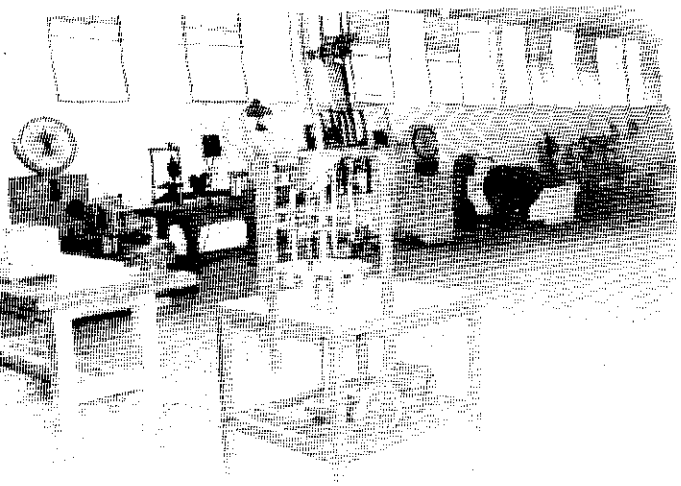

Fig. 1: Isometric View of the potato cutting machine.

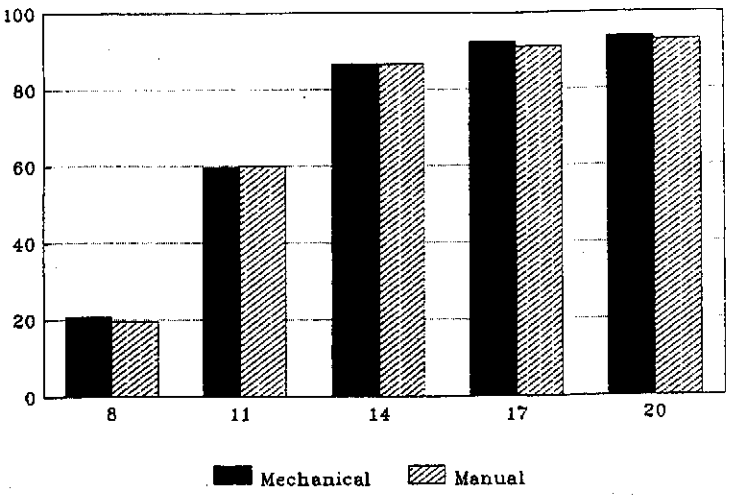


Fig. 2: Total plants germination (%)

## Conclusions and Suggestions

The following conclusions were drawn from the study:

1. The machine can be successfully used in the process of mechanizing potato production.
2. The operation of feeding and collecting the cut seed pieces were found cumbersome therefore, these operations should be made automatic.
3. The seed tubers should be graded before they are fed to machine for cutting operation.
4. The electric motor as power source was found suitable for the present model. However, due to unavailability of electricity at most of the Pakistani farms, an internal combustion engine of the same power output should be added.
5. The uncovered moving parts of the machine should be protected and guarded properly so that any chances of accidents may be avoided.

## References

Akhtar, M., 1987. Vegetables of Punjab. Dept. of Agriculture, Govt. of the Punjab, Lahore.

Chaudhry, A.H., 1988. Potato planting in the Punjab. Dept. of Agriculture, Punjab Agriculture Information Bureau, Lahore.

Lipskil, N.Y., N.N. Lokhach, A.S. Moisa and A.R. Kolin 1992. An automated unit for potato seed cutting Agril. Eng. Shafi, A. 1990. Design and development of a potato seed cutter. M.Sc. Thesis, Univ. of Agri Faisalabad. Abstract, 7: 15-19.