International Journal of Agricultural Engineering, Vol. 3 No. 1 (April, 2010) : 62-67

Research Paper :

Performance evaluation of sapota fruit grader

P.D. UKEY AND P.A. UNDE

Accepted : *January, 2010*

See end of the article for authors' affiliations

Correspondence to:
P.D. UKEY
Department of Agriculture Process Engineering, Pad. Dr. D.Y. Patil, College of Agriculture Engineering and Technology, Talsande, KOLHAPUR (M.S.) INDIA

ABSTRACT

The experiments were conducted to study the performance of sapota fruit grader. The effect of three machine parameters *viz.*, roller speed (111 to 334 rpm), roller inclination (0 to 6^0) and gap between the rollers (35 to 67 mm) on capacity, efficiency and performance of fruit grader was studied. The optimum capacity at maximum efficiency (89.48%) found was 1440 kg/hr. The performance index of 13.42 was seen for best operation of the machine. The ratio of cost for manual to mechanical grading was 20.8:1

Key words : Fruits, Sapota, Grader, Performance, Efficiency

Sapota (*Manilkara archras* (Mill) Forsberg) is an important fruit crop in India. It is mainly consumed as table purpose fruit. In India area under this crop is estimated to be 64,400 ha with annual production of 8,03,000 tonnes. The average productivity in India is 12.46 t/ha. In Maharashtra, the area under this crop is nearly 14,897 ha with a production of about 1,57,430 tonnes and average productivity of 10.57 t/ha (Singhal, 1999). The sapota grading is an important operation for quality market price trading and commercial purpose. Grading of sapota fruits is done manually either by hand picking or through sieves. Both methods are time and labour consuming. The efficient grading operation on the basis of physical dimensions of the sapota can be made with the help of mechanical sapota grader. Different types of grader have been developed for different fruits and vegetables such as mechanical grader, electronic size and grader, divergent belts, perforated belts, divergent rollers, weight cups etc. Roller grading is fast, accurate and causes little damage to the fruits as compared to other grading machines. The continuous rotation of rollers gives an opportunity to individual fruits to register its maximum dimensions with the spacing between the rollers. Keeping this in view a divergent roller type sapota fruit grader was developed.

METHODOLOGY

A divergent roller type sapota fruit grader was designed and developed in the department of Agricultural Process Engineering M.P.K.V., Rahuri. The main components of the grader are grading unit, feeding unit, collection unit and power transmission unit (Plate 1). Grading unit consists of main frame, grading rollers and guiding channels. The main frame of the grading unit was fabricated in rectangular shape with an overall dimension of 1220 mm x 1000 mm x 560 mm on which all the accessories are mounted. The frame is made up of 30 mm MS angles. Mild Steel pipe (OD = 30 mm and ID = 26 mm) was used for grading rollers. The overall length of grading rollers was kept 1400 mm. The guiding channels are made of 20 gauge GI sheet. The overall dimensions of guiding channels are 1160 mm x 90 mm. The feeding hopper is fabricated trapezoidal in shape. The feeding

Plate 1 : Grading machine

unit (hopper) is fabricated in 20 gauge GI sheet. The overall dimension of the feeding unit is 960 mm x 1020 mm x 260 mm. The collection platform is partitioned into three compartments on each side, at the distance of 350 mm, 510 mm and 350 mm, respectively from feed end to the rear end. The collection platform is made of 20 gauge GI sheet. The overall dimension of the collection platform is 1220 mm x 1000 mm. x 200 mm. The main purpose of compartment is to avoid intermixing of fruits of different grades. The grading rollers were driven by 1-hp single-phase electric motor through sprocket chain arrangement. Speed reduction was achieved by using two stage reductions in rpm using different diameter pulleys. Sapota used as a grading material to evaluate the performance of the machine. It was graded into three size grades at every combination of speed, inclination and gap between the rollers. The grading machine was operated by keeping two parameters constant at a time and changing third one. Thus giving seventy five combinations of machine parameters. Five different speeds of rollers (111, 133, 166, 223 and 334 rpm) were combined with three different gaps of rollers (35 – 61, 38 – 64 and 41 – 67 mm) and five different angle of inclination of the rollers (0^0, 1.5^0, 3.0^0, 4.5^0 and 6.0^0) were taken for the study. The time required for grading and weight at each combination was recorded and capacity was calculated. For grading efficiency, the sample was taken in the ratio of 1:4:1 (Grade I: Grade II: Grade III) for different combination of machine parameters. By comparing, mean diameter of the fruit collected in any grade to that grade gap range, size of fruits under or over the gap range was decided. The test was replicated three times and average grading efficiency was calculated. The grading efficiency was calculated by using formula given by Singh (1980).

$$E_s = \frac{W_t - (W_u + W_o)}{W_t} \times 100 \quad (1)$$

where,
E_s = Grading efficiency, %
W_t = Total weight sample (g)
W_u = Weight of under size fruits (g) and
W_o = Weight of over size fruits (g)

The performance index of the divergent roller type grader was calculated by using the following equation.

$$P.I. = \frac{\text{Efficiency x Capacity (t/hr)}}{\text{Unit cost of operation (Rs./t)}} \quad (2)$$

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been summarized under following heads:

Capacity of fruit grader:

The results of the experiments in terms of capacity and grading efficiency at different speeds, inclinations and gaps between the rollers are discussed. The relationship between inclination and gap between the rollers on capacity at different speeds is plotted and shown in Fig. 2 Each point represents average of three replications. Fig. 2 (a) through Fig. 2 (e) shows that, the capacity increased with increasing inclinations of rollers and gap between the rollers for all speeds. The capacity also increased with increase in speed of rollers. The capacity varied between 508 to 1728 kg/hr. The average capacity was found 1118 kg/hr. The maximum capacity was seen at speed S_5 (334 rpm), whereas the minimum capacity was observed at speed S_1 (111 rpm). The maximum capacity was observed at inclination, I_5 (6.0^0) whereas the minimum capacity was obtained at inclination I_1 (0^0). The results of capacity were found in agreement with findings of Nevkar (1990) and Patil and Patil (2002).

Efficiency of fruit grader:

The efficiency varied between 51.48 to 89.48 % for all machine parameter combinations. The average efficiency obtained was 70.48%. The maximum efficiency was found in case of $S_4I_4G_2$ (S_4 = 223 rpm, I_4 = 4.5° and G_2 = 38 to 64 mm) and the minimum efficiency was found in case of $S_1I_5G_3$ ((S_1 = 111 rpm, I_5 = 6.0^0 and G_3 = 41 to 67 mm). The relationship between inclination and gap between the rollers on efficiency at various speeds is plotted and shown in Fig. 3 (a) to Fig. 3 (e). The Fig. 3 shows that the efficiency increased with increase in inclination and gap between the rollers for all speeds. The efficiency increased upto 4.5°inclination and 223 rpm speed of rollers, after that it decreased with further increase in the inclination and speed of rollers and gap between the rollers. The maximum efficiency was found in case of speed 223 rpm, whereas the minimum efficiency was obtained for speed 111 rpm.

Performance of fruit grader:

The data on effect of machine parameters on the performance index are tabulated and given in Table 1. The data show that the performance index varied with respect to the speed of rollers, inclination of rollers and gap between the rollers. The performance index varied between 2.80 to 13.42. The average performance index of grader was obtained 8.11. The maximum performance

Table 1: Effect of machine parameters on performance index

Roller speed (s) rpm	Inclination (I) degree	Gap between rollers (G), cm	Performance Index
S_1	I_1	G_1	2.80
S_1	I_1	G_2	3.95
S_1	I_1	G_3	4.07
S_1	I_2	G_1	3.19
S_1	I_2	G_2	4.32
S_1	I_2	G_3	5.10
S_1	I_3	G_1	3.53
S_1	I_3	G_2	4.88
S_1	I_3	G_3	5.47
S_1	I_4	G_1	3.78
S_1	I_4	G_2	5.95
S_1	I_4	G_3	6.52
S_1	I_5	G_1	3.61
S_1	I_5	G_2	6.54
S_1	I_5	G_3	6.17
S_2	I_1	G_1	3.80
S_2	I_1	G_2	4.68
S_2	I_1	G_3	5.25
S_2	I_2	G_1	4.09
S_2	I_2	G_2	5.18
S_2	I_2	G_3	6.43
S_2	I_3	G_1	4.73
S_2	I_3	G_2	6.70
S_2	I_3	G_3	7.01
S_2	I_4	G_1	5.54
S_2	I_4	G_2	8.43
S_2	I_4	G_3	8.40
S_2	I_5	G_1	5.61
S_2	I_5	G_2	8.26
S_2	I_5	G_3	7.79
S_3	I_1	G_1	4.27
S_3	I_1	G_2	5.32
S_3	I_1	G_3	6.46
S_3	I_2	G_1	4.65
S_3	I_2	G_2	6.29
S_3	I_2	G_3	8.08
S_3	I_3	G_1	5.72
S_3	I_3	G_2	7.54
S_3	I_3	G_3	9.15
S_3	I_4	G_1	6.73
S_3	I_4	G_2	9.65
S_3	I_4	G_3	9.91
S_3	I_5	G_1	7.70
S_3	I_5	G_2	9.32
S_3	I_5	G_3	9.86
S_4	I_1	G_1	5.41
S_4	I_1	G_2	6.99
S_4	I_1	G_3	6.89
S_4	I_2	G_1	6.32
S_4	I_2	G_2	8.09
S_4	I_2	G_3	8.25
S_4	I_3	G_1	7.22
S_4	I_3	G_2	10.06
S_4	I_3	G_3	9.34
S_4	I_4	G_1	9.73
S_4	I_4	G_2	13.42
S_4	I_4	G_3	10.35
S_4	I_5	G_1	10.88
S_4	I_5	G_2	12.07
S_4	I_5	G_3	10.16
S_5	I_1	G_1	5.89
S_5	I_1	G_2	6.95
S_5	I_1	G_3	6.75
S_5	I_2	G_1	6.78
S_5	I_2	G_2	8.36
S_5	I_2	G_3	11.28
S_5	I_3	G_1	7.92
S_5	I_3	G_2	9.91
S_5	I_3	G_3	12.22
S_5	I_4	G_1	9.85
S_5	I_4	G_2	11.53
S_5	I_4	G_3	12.76
S_5	I_5	G_1	11.49
S_5	I_5	G_2	12.83
S_5	I_5	G_3	12.81

Contd.…… Table 1

Table 1 contd….

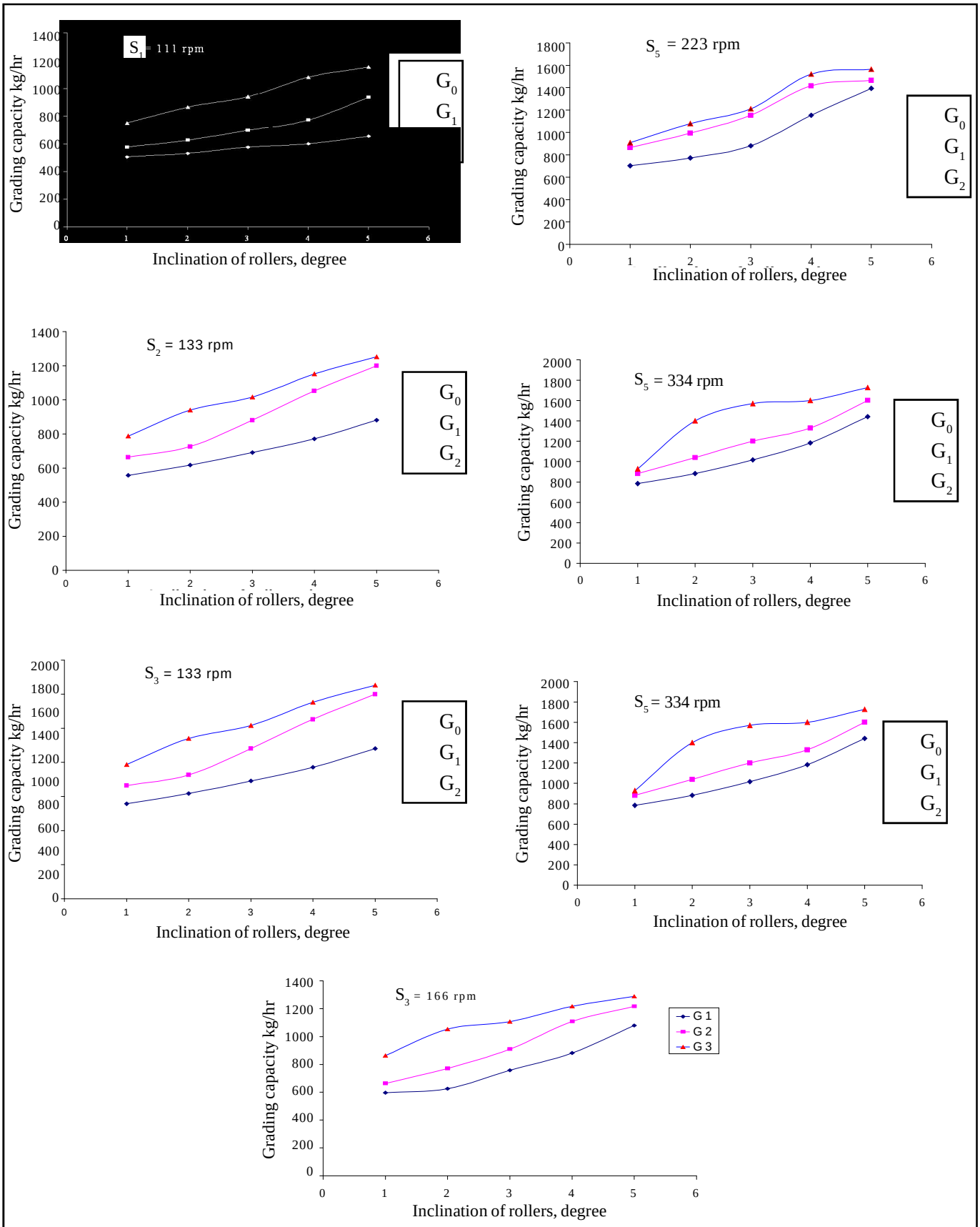

Fig. 2 : Effect of inclination and gap between rollers on capacity at various speed

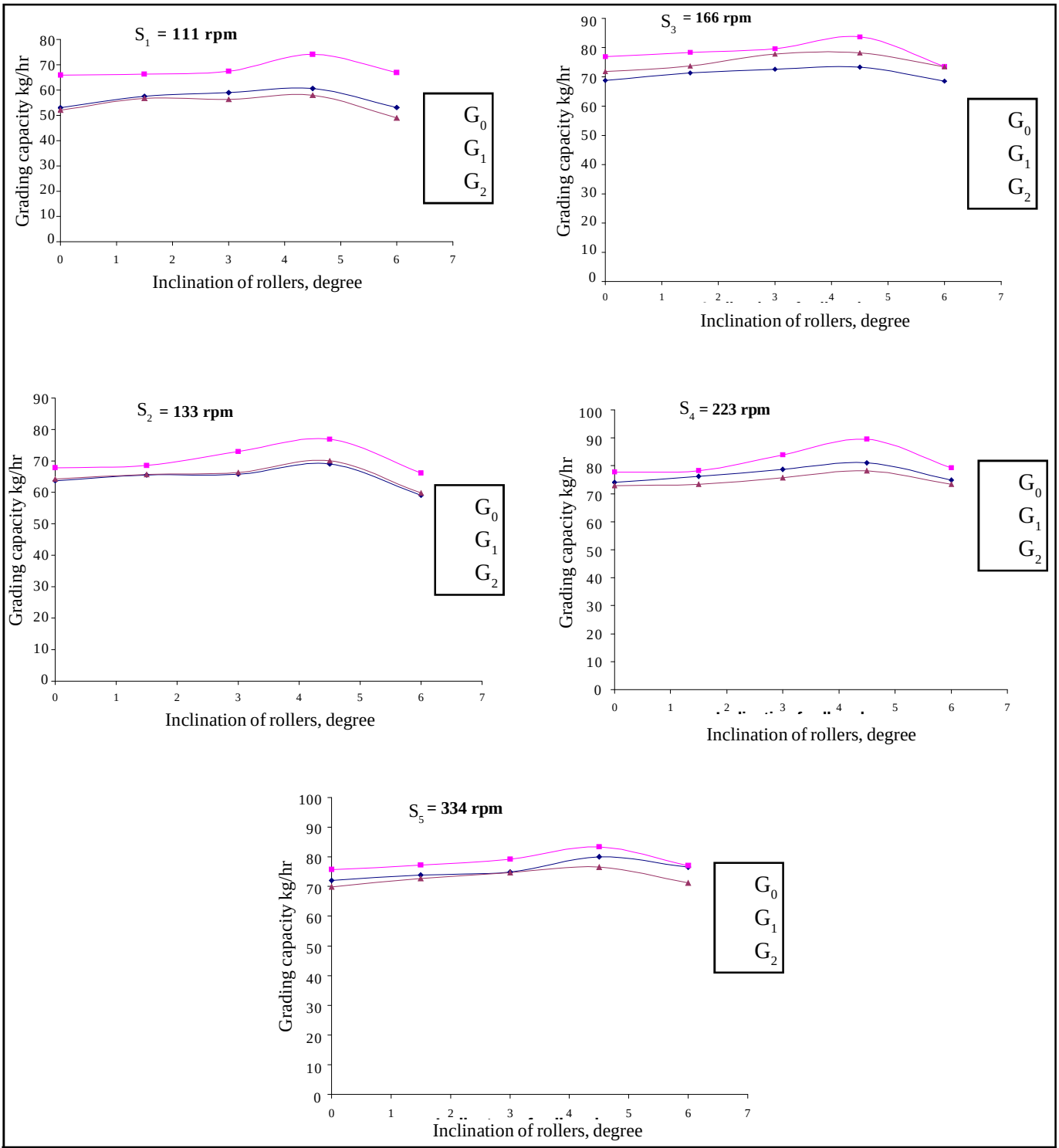

Fig. 3 : Effect of inclination and gap between rollers on efficiency at

index was found at $S_4I_4G_2$ (S_4 = 223 rpm, I_4 = 4.5^0 and G_2 = 38 to 64 mm) and the minimum performance index was found in case of $S_1I_1G_1$ (S_1 = 111 rpm, I_1 = 0^0 and G_1 = 35 to 61 mm).

Cost- economics of fruit grading:

Cost-economics of sapota grading was determined and given in Table 2. The cost for manual grading was found to be Rs. 200 per tonne. Whereas the cost for machines grading obtained was Rs. 9.60 per tonne. The

Table 2: Cost economics of sapota grading

Method/Cost	Details	Cost (Rs)
I) Manual grading		
a) Fixed charges	Nil	Rs.: 40/- per day
b) Variable charges	1 labour @ Rs.: 40/- per day capacity 2 quintal	Rs. 200/- per tonne
Labour	per day	
Total cost of grading		
II) Mechanical grading		
A) Fixed cost		
1) Depreciation	@10 % ,life 10 year	
2) Intrest on investment	Salvage value 10 %	1625/-
Total fixed cost	12 %	1950/-
	Working days in year 150 days.	----------
	Capacity of machine 14.40 quintal/hr i.e115.2 quintal per day (one day is of eight hour).	3575/- per year
		a) Rs. 24/- per day
B)Variable cost		
1) Repair and maint.	@ 2% = Rs.325	
2) Labour charges	2 labour @RS. 40 per day	
3) Electricity	1 KWH X Rs.4 per unit	02/- per day
		80/-
		04/-
		----------
		b) Rs. 86/-day
Total cost of machine grading	(a + b) = Rs. 110/- per day	
	= Rs. 9.60/- per tonne	
Ratio of cost for manual to mechanical grading	200 : 9.60 = 20.8 : 1	

ratio of cost for manual to mechanical grading was 20.8: 1.

Conclusion:

The grader needs 1 hp to drive its various components for the required load. The capacity obtained was 1440 kg/hr at $S_4I_4G_2$ combinations. The efficiency of the machine varied between 51.48 to 89.48 %. The best combination of the machine for grading sapota fruits is $S_4I_4G_2$ (S_4 = 223 rpm, $I_4 = 4.5^0$ and G_2 = 38 to 64 mm). The maximum performance index of 13.42 was found in case of $S_4I_4G_2$. The ratio of cost for manual to mechanical grading obtained was 20.8:1

Authors' affiliations:
P.A. UNDE, Department of Agriculture Process Engineering, College of Agriculture, KOLHAPUR (M.S.) INDIA

REFERENCES

Nevkar, G. S. (1990). Developement and performance testing of divergent roller type fruit sorting machine. M. Tech. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri (India), pp. 52-95

Patil, V.B. and Patil, J.S. (2002). Design, development and performance testing of grader for sapota fruits. B. Tech. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri (India), pp. 13-19

Singh, B. (1980). Development and performance of different belt speed expanding pitch type potato grader. *J. agric. Engg*., **17**(2) : 69.

Singhal, V. (1999). *Sapota in Indian Agriculture*. Indian economic data research center, New Delhi, pp. 174.

***