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Research Paper :

Design and development of sapota fruit grader

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ABSTRACT

Grading is a vital as well as pre requisite step in marketing and processing of fruits. The normal practice in India is to grade manually on size basis. One person grades 200 kg of fruits in a day. In order to increase the output of fruit grading and save time and labour, a sapota fruit grader based of divergent roller type principle was designed and developed. The best combination of roller speed, its inclination and roller gap was found to be 223 rpm, 4.5^0 and 38 to 64 mm, respectively for highest efficiency of 89.5%. The capacity of machine was 1440 kg/hr and costed Rs.11,450/- (without electric motor).

Key words : Sapota fruits, Grader, Performance, Efficiency, Design and development, Fruit grader

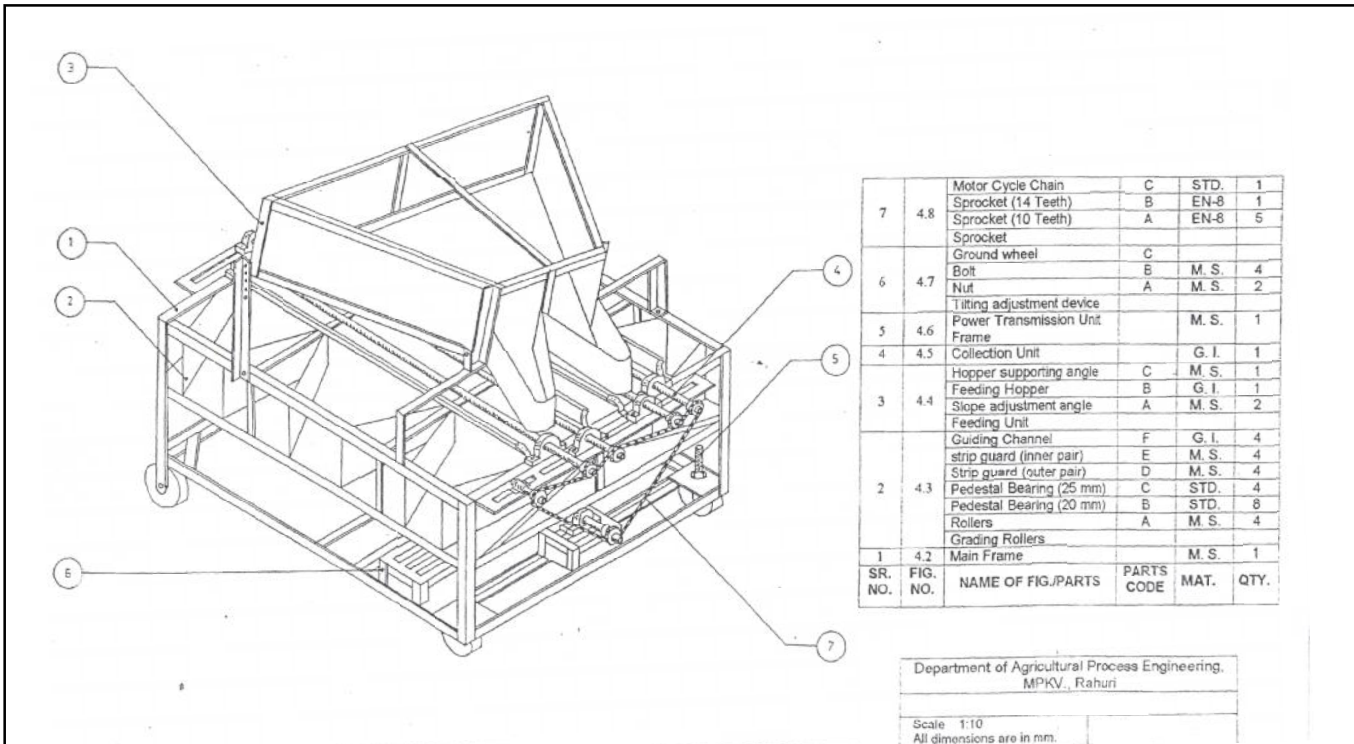
Sapota is grown in almost all the Southern states of India. The area under this crop in India is estimated to be 64,400 ha with annual production of 8,03,000 tonnes. The average productivity of India is 12.46 t/ha. In Maharashtra, the area under this crop is nearly 14,897 ha with a production of about 1,57,430 tonnes. The average productivity of sapota in Maharashtra is 10.57 t/ha (Singhal, 1999). In market, grading provides basis for pricing, buying and selling. Grading is thus a vital as well as pre- requisite step in processing of fruits. Roller grading is fast, accurate and causes little damage to the fruits and is extensively used in fruit industries. According to fruit market survey, size of the fruits plays most important role in fetching remunerative market price. Manually assisted mechanical grading will be the probable solution to overcome time consuming, labour intensive and cost problems and it will help satisfy the farmer's need at low cost. Grading of fruits into various size and shape categories is usually one of the first and important steps in processing operation. Grading of fruits is a very crucial operation as it determines the price, fetched to the growers. The fruits are graded for size and quality. Grading and standardization brings about an overall improvement not only in the marketing system but also in raising quality consciousness. The normal practice in India is to grade manually. There are many principles being used in grading machines. Different types of graders have been developed for different fruits and vegetables such as mechanical grader, electronic size and colour grader, divergent belts, perforated belts, divergent rollers, weight cups etc. In view of this a sapota fruit grader based on divergent roller principle was designed and developed.

METHODOLOGY

A divergent roller type Sapota fruit grader was designed and developed in the department of Agricultural Process Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.). The basic structure of machine consisted of four units *viz.*, grading unit, feeding unit, collection unit and power transmission unit (Fig. 1)

Grading unit:

Grading unit consisted of main frame, grading rollers and guiding channels (Fig. 2). 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 M. S. angles. Mild steel pipe (OD = 30 mm and ID = 26 mm) was used as grading rollers. The overall length of grading rollers was 1400 mm. Two pairs of the rollers were mounted side by side on the grading frame exactly below the feeding unit. The rollers were mounted on the main frame with the help of slotted type M. S. flat at the feed end and rear end. The rollers were rotated by using sprocket and chain arrangement provided at the feed end while rear end was attached on revolving bearing pedestal. The sprockets were connected to the power transmission unit while the other end (rear end) was movable. The progressive increasing gap between the rollers was achieved by sliding the rear end as well as feed end of the rollers as per requirement. The precision was provided at the rear end to increase the gap upto



SR. NO.	FIG. NO.	NAME OF FIG./PARTS	PARTS CODE	MAT.	QTY.
7	4.8	Motor Cycle Chain	C	STD.	1
		Sprocket (14 Teeth)	B	EN-8	1
		Sprocket (10 Teeth)	A	EN-8	5
		Sprocket			
6	4.7	Ground wheel	C		
		Bolt	B	M. S.	4
		Nut	A	M. S.	2
		Tilting adjustment device			
5	4.6	Power Transmission Unit Frame		M. S.	1
4	4.5	Collection Unit		G. I.	1
3	4.4	Hopper supporting angle	C	M. S.	1
		Feeding Hopper	B	G. I.	1
		Slope adjustment angle	A	M. S.	2
		Feeding Unit			
2	4.3	Guiding Channel	F	G. I.	4
		strip guard (inner pair)	E	M. S.	4
		Strip guard (outer pair)	D	M. S.	4
		Pedestal Bearing (25 mm)	C	STD.	4
		Pedestal Bearing (20 mm)	B	STD.	8
		Rollers	A	M. S.	4
		Grading Rollers			
1	4.2	Main Frame		M. S.	1

Department of Agricultural Process Engineering, MPKV., Rahuri

Scale 1:10
All dimensions are in mm.

Fig. 1 : Grading machine

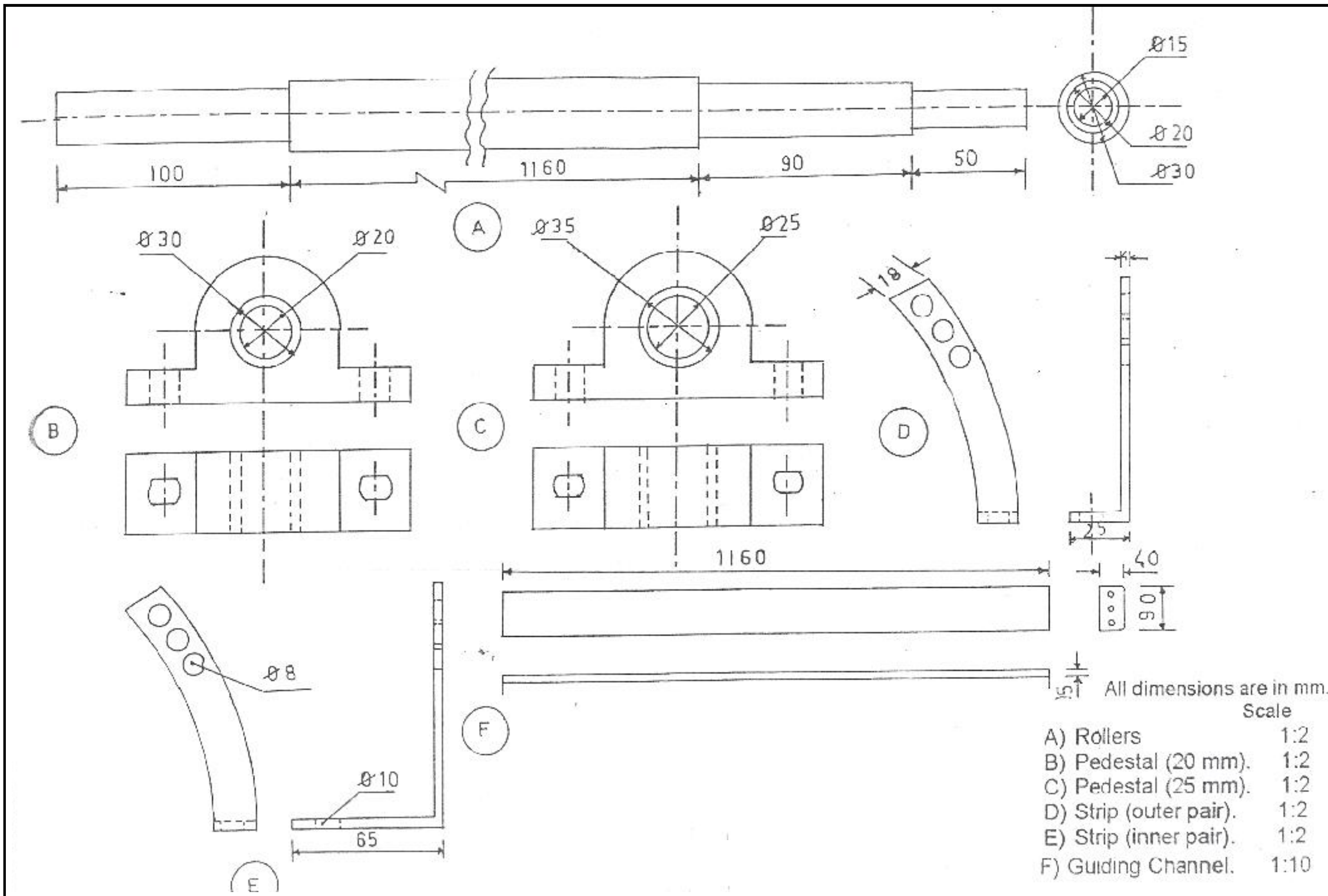


Fig. 2 : Grading rollers

maximum size of fruits. The rollers were coated by powder coating for getting the smoothness and avoid damage to the fruits, while travelling between the rollers. The guiding channels were made up of 20 gauge G. I. sheet. The overall dimensions of guiding channels were 1160 mm X 90 mm, respectively. The guiding channels were placed between the outer sides of the rollers on each pair to avoid mixing of fruits feed to the rollers and to avoid dropping outside. The provision was made to adjust the slope of guiding channels.

Feeding unit:

The feeding hopper was fabricated in trapezoidal shape (Fig. 3). The feeding unit/hopper was made using 20 gauge G. I. sheet. The overall dimensions of the feeding unit were 960 mm X 1020 mm X 260 mm. A felt cloth (hotlone) was fixed over the hopper as cushioning material to avoid damage and bouncing of fruits.

Collection unit:

The increasing spacing between the rollers from feed end to the rear end on both sides allowed the fruits to grade into three different sizes. These size graded fruits dropped on collection platform. The collection platform was 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 overall dimension of the collection platform was 1220 mm X 1000 mm. X 200 mm. The collection unit was made to get three different grades of fruits by using wall / divider. These dividers make the channels for the separation of fruits when the fruits dropped on the collection platform. A felt cloth (hotlone) was fixed over the receiving ramp as cushioning material and avoid damage to fruits due to impact during collection.

Power transmission unit:

A power transmission (unit) frame was fabricated by using M.S. angle and fitted at the bottom of the main frame (Fig. 4). The power transmission unit was divided into two parts, *i.e.* sprockets-chain arrangement and speed reduction unit. The grading rollers were driven by 1-hp single-phase electric motor through sprocket chain arrangement. Speed reduction required was achieved by using two stage reduction in rpm using different diameter pulleys. The grading of sapota was done at five different speeds *viz.*, 111, 133, 166, 223 and 334 rpm. The sapota grading machine consisting the above four units is shown in Fig. 4.

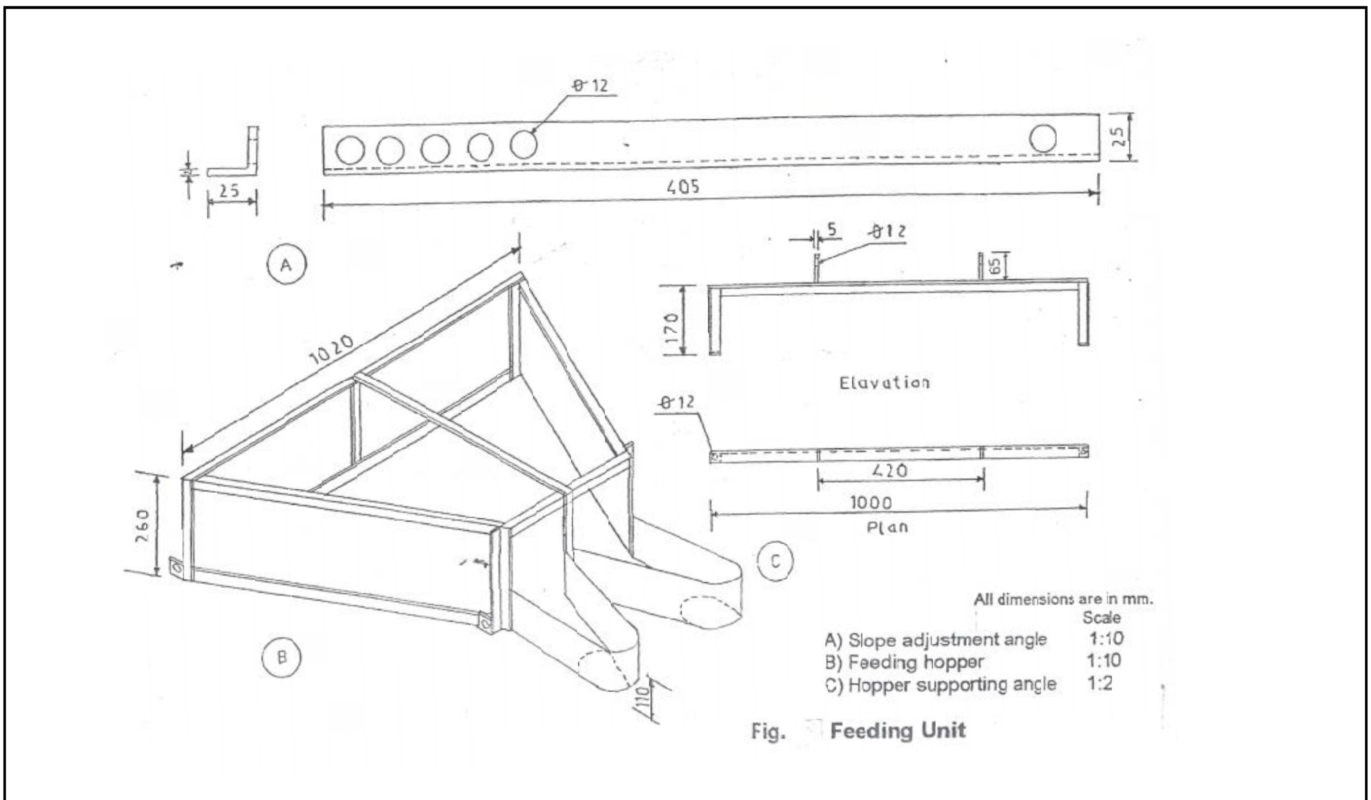


Fig. 3 : Feeding unit

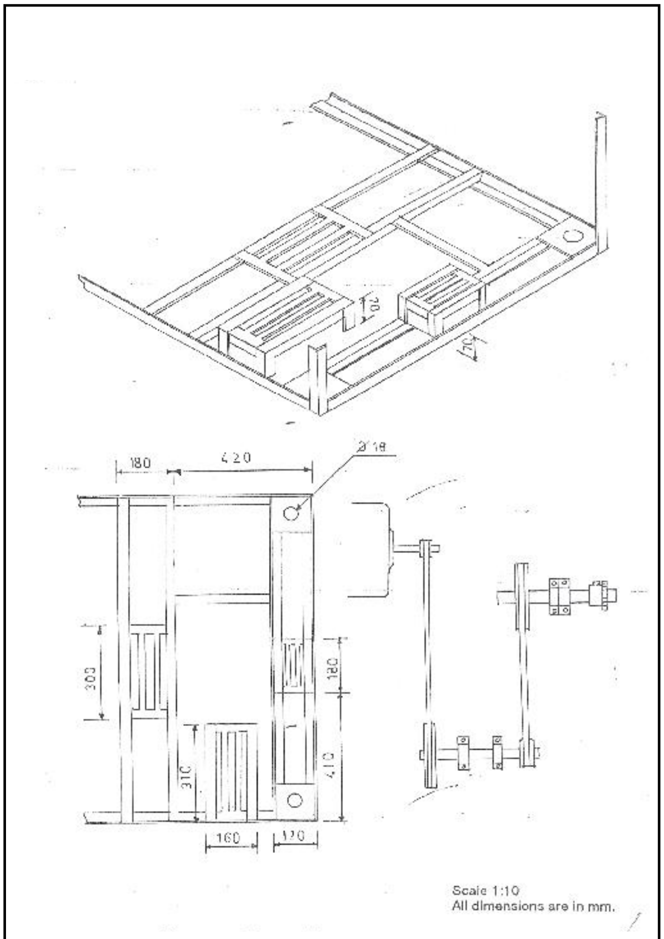


Fig. 4 : Power transmission unit

Testing:

The machine was tested for sapota fruits (var. Kalipatti). 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 grading machine was operated by keeping two parameters constant at a time and changing third one. Thus giving seventy five combinations of machine parameters. The time required for grading and weight at each combination was recorded and the capacity was calculated. 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 relationship given by (Singh, 1980)

$$Es = \frac{Wt - (Wu + Wo)}{Wt} \times 100 \quad .....(i)$$

where,

ES = Grading efficiency, %

Wt = Total weight of sample (g)

Wu = Weight of under size fruits (g) and

Wo = Weight of over size fruits (g).

RESULTS AND DISCUSSION

The results of the experiments in terms of mean values of capacity and grading efficiency at different speeds, inclinations and gaps between the rollers have been discussed. The relationship between inclination and speed of rollers on capacity at different gaps shown in Fig 5. It shows that the capacity increased with increase in inclination of the machine and speed of rollers for all gaps between the rollers. Capacity also increased with increase in the gap between the rollers. The maximum

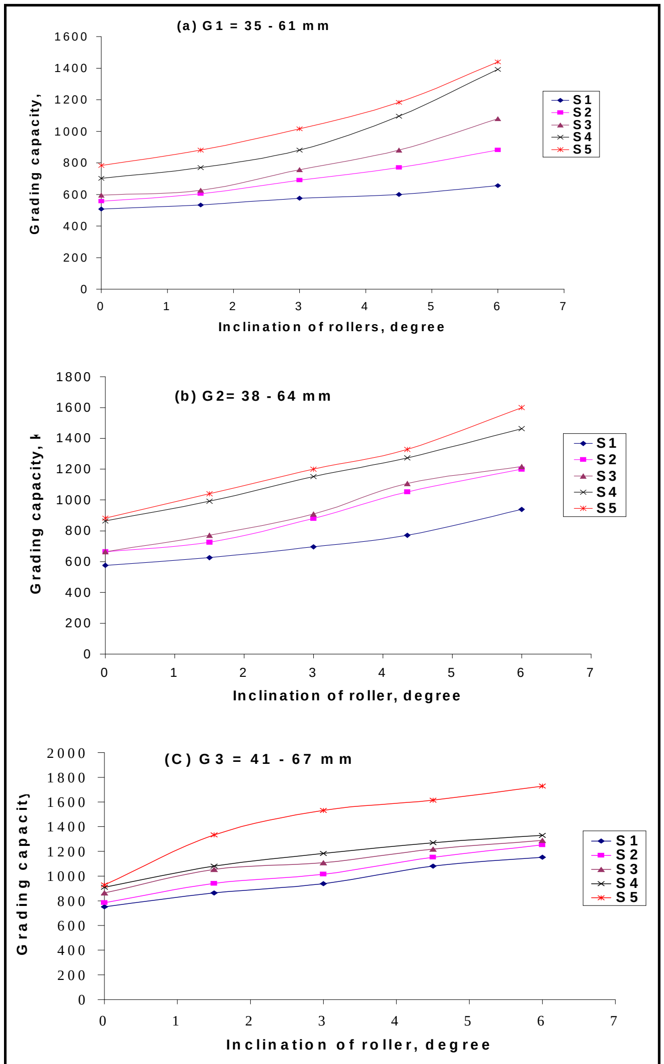


Fig. 5 : Effect of inclination and speed of rollers on capacity at various gaps

capacity was found at gap G_3 (41 mm to 67 mm) whereas, the minimum capacity was found at gap G_1 (35 mm to 61 mm). The maximum capacity of 1728 kg/hr was found in case of combinations $S_5I_5G_3$ (S_5 = 334 rpm, $I_5 = 6.0^0$ and G_3 = 41 to 67 mm)and the minimum capacity of 508 kg/hr was found combinations $S_1I_1G_1$ (S_1 = 111 rpm, $I_1 = 0^0$ and G_1 = 35 to 61 mm).The results of capacity are in agreement with Nevkar (1990) and Patil and Patil (2002).

The relationship between inclination of the machine and speed of the roller on efficiency at different roller gaps is shown in Fig.6. The grading efficiency of the

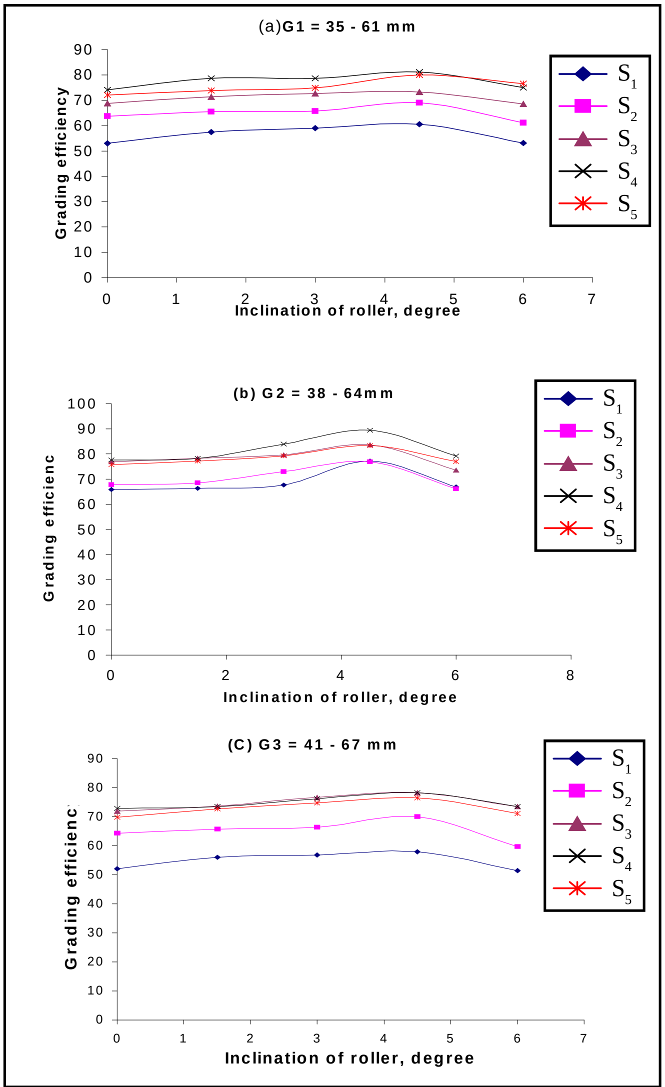


Fig. 6 : Effect of inclination and speed of rollers on efficiency at various gaps

machine varied between 51.5 to 89.5 %. Fig. 6 shows that the efficiency increased with an increase in the inclination and speed of rollers for all the gaps. The maximum efficiency was found at gap G_2 (38 to 64 mm) whereas the minimum efficiency was found at roller gap G_3 (41 to 67 mm). The optimum capacity for maximum grading efficiency (89.5 %) of the machine was 1440 kg/hr. The results of efficiency were also found in agreement with Nevkar (1990) and Patil and Patil (2002).

Conclusion:

The divergent roller type fruit grader was found to have a maximum capacity of 1728 kg/hr. The efficiency of the machine varied between 51.48 to 89.5 %. The best combination of roller speed, inclination of rollers and roller gap of the machine for grading sapota fruits at high efficiency was found to be $S_4I_4G_2$ (S_4 = 223 rpm, I_4 = 4.5° and G_2 = 38 to 64 mm) which gave 89.5% grading efficiency with a machine capacity of 1440 kg/hr.

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