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RESEARCH ARTICLE :

Study of existing fruits and vegetable graders for on-farm grading of onion

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SUMMARY : A lab experiment was carried out to evaluate the effect of existing fruits and vegetable grader for on-farm grading of onion. To conduct the experiment two selected onion varieties, Satara Garva and Arka Kalyan were used to evaluate the effectiveness, bulb damage and capacity of graders. Existing proto-type fruit and vegetables or onion graders like motorized oscillatory and roller type onion size graders available at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur and manual operated sieving type onion size grader available at Indian Institute of Horticultural Research, Hesaragatta, Bengaluru. The grading performance results indicated that oscillatory type onion size grader was not suitable for onion varieties especially large sized bulbs. The motorized roller type onion size grader was unsuitable for onion grading and in this grader bulb damage during grading was unacceptably high. The effectiveness, bulb damage and capacity of manual operated sieve type onion grader was found to be 0.698, 539 kg h^{-1} and 9.67% for Satara Garva and 0.583, 481 kg h^{-1} and 5.75% for Arkha Kalyan varieties. The compression study of performance of manual operated sieve type onion size grader with oscillatory type and motorized roller type grader for the selected varieties was shown that manual operated sieve type grader was reasonably good for both Satara Garva and Arka Kalyan varieties but it needs more human energy to oscillate the machine.

KEY WORDS :
Onion varieties, Grader, Effectiveness, bulb damage, Capacity

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BACKGROUND AND OBJECTIVES

Onion (*Allium cepa*, L.), a plant species of the family *Alliaceae* with food and medical properties, contains many essential vitamins and mineral. It is native to Asia and the Middle East and has been cultivated for over five thousand years. It is seasonal in production but required round the year (Akbari, 1997). Onion is a bulbous biennial or perennial herb and bulbs are formed by the attachment of swollen leaf bases to the underground part of stem. Onion bulbs contain 11 amino acids, 100 g of raw onion bulb contains about 501 µg vitamin 'A', 0.03 mg of thiamine, 0.04 mg of riboflavin, 0.02 mg of niacin and 9 mg of ascorbic acid and rest the carbohydrates which make up the dry matter of the bulb. Onion has many uses as folk medicine and recent reports suggest that onion plays an important role in preventing heart diseases and other ailments (Dabhi, *et al.*, 2010).

Grading plays a major role in the food processing industries. The purpose of grading onion is to conform the commercial standards and also to facilitate marketing. Grading of fruits and vegetables is one of the most important operations since it adds value to the product and gives better economic return to the producer. Grading generally done on the basis of size and shape and it is important for marketing uniform high quality produce. Grading gives direct benefit to all parties concerned in the buying and selling transactions. It is essential to the business of processors, wholesalers and retailers. Consumers get a benefit whenever the packages carry the official grade marking (Schoenemann, 1977).

Grading of fruits and vegetables by human eye judgment is quite difficult. It takes a long time to do grading and hence labour charges will be more. Moreover, there are chances of mixing of other sizes of fruits. The manual grading is labour intensive, time consuming and not standardized. The quality perception varies from person to person hence, the uniformity of graded material becomes doubtful (Shahir and Thirupathi, 2009). Therefore, farmers are looking forward to have an appropriate crop grading machine in order to alleviate the labour shortage and obtain better quality of agricultural products. Keeping in view of the market requirements as desired by the WTO, quality control by proper grading demands a grading machine that can be used on-farm level and within the purchase power of an ordinary farmer (Ashraf *et al.*, 2007).

Onion graders developed, fabricated and marketed in India are of screen or roller type having the capacity of 10 to 12 t h^{-1} with the cost of Rs 10 lakh or more. These are expensive and beyond the reach of ordinary onion growing farmers having small land holding.

RESOURCES AND METHODS

Onion grading trials were conducted with three existing proto-type onion graders (motorized oscillatory and roller type onion size grader) available at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur (Fig.1and2) and manual operated sieving type onion size grader available at Indian Institute of Horticultural Research, Hesaragatta, Bengaluru (Fig.3). The lab experiments were conducted in the month of January, 2015. Two selected onion varieties, Satara Garva and Arka Kalyan were used to evaluate the effectiveness, bulb damage and capacity of graders.

Fig. A : Existed different types of onion size graders

The motorized roller type onion grader has been designed to separate the onions into three grades: d”30, 30-40 and 40-50 mm. The oscillatory type onion grader has been designed to grade onions into three grades: 30-40, 40-60 and e”60 mm. The manual operated sieve type onion size grader of IIHR has been designed to separate the onions into three grades: d”30, 30-50 and 50-70 mm. A 0.5 hp 1400 rpm motor was used in the roller and oscillatory onion graders. Four revolutions of the motor gives two cycles of oscillation in the oscillatory type onion

size grader and complete one rotation of rollers in roller type onion size grader. In each trial, about 8 kg of bulk onions was fed to the grader and the graded onions were collected from different outlets and weighed. The bulk onion samples were also manually separated into different grades to know the distribution of bulb size in the bulk. The percentage of onion de-skinned/damaged during each trial was also recorded based on visual observation.

Grading operation :

During each trial, 8 kg of bulbs were fed to the grader. Initially the bulk onion bulbs of each variety were graded manually into four desired grades as: <40, 40-50, 50-60 and >60 mm for Satara Garva and Arka Kalyan onion varieties and each bulb in the sample was given number for identification of its classified grade to which it belonged. The weight of bulbs in each classified grade were noted initially and the grading effectiveness for each grade was computed on the basis of fraction of bulbs collected at respective outlet out of the total onion bulbs fed of that grade.

The percentage of feed collected and percentage of target onion size collected from a particular outlet was calculated by using the following relationships:

$$\text{Feed collected (\%)} = \frac{\text{Weight of onion in the outlet (kg)}}{\text{Weight of feed (kg)}} \times 100$$

$$\left[\begin{array}{c}\text{Target onion}\\ \text{size collected (\%)}\end{array}\right] = \frac{\text{Weight of target size collected in the outlet (kg)}}{\text{Weight of onion in the oulet (kg)}} \times 100$$

Grading effectiveness :

The grading effectiveness of existed grader was estimated by multiplying all outlet effectiveness that can be calculated by using following relation :

$$\left[\begin{array}{c}\text{Effectiveness for given}\\ \text{grade of onion bulb, } \varepsilon_1, \varepsilon_2 \text{ \& } \varepsilon_3\end{array}\right] = \frac{\text{Weight of target size onion in the outlet (kg)}}{\text{Weight of target size onion in the feed (kg)}}$$

$$\text{Overall grading effectiveness of grader } \varepsilon = \varepsilon_N \times \varepsilon_O \times \varepsilon_P$$

where,

ε_1, ε_2, ε_3 = Effectiveness for target grade-1, grade-2 and grade-3.

Bulb damage :

The mechanical damage to onion bulbs during grading operation was determined by visual observation. The graded bulbs were manually sorted for damage of bulbs due to abrasion and the weight of total damaged bulbs collected in each outlet was noted. Thereafter, the damage percentage was computed using the following relation:

$$\text{Mechanical damage (\%)} = \frac{D}{W} \times 100$$

where,

D = Weight of damaged onion bulbs in all outlets, kg

W = Total weight of onion bulbs in all outlets, kg

Grading capacity :

The grading capacity of the onion grader was estimated by weighing the total onion bulbs collected per unit time from the all outlets of the grader and was calculated by using the following relationship:

$$\text{Grading capacity (kg/h)} = \left[\frac{\text{Weight of onion bulbs collected in all outlets (kg)}}{\text{Grading time (h)}}\right]$$

OBSERVATIONS AND ANALYSIS

Trials were conducted with three prototype onion graders, two motorized and one manually operated, which existed at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur and Indian Institute of Horticultural Research, Hesaragatta, Bangalore using two selected onion varieties (Satara Garva and Arka Kalyan). The performance parameters namely, feed collected (%) in each outlet, grading effectiveness (%), bulb damage (%) and grader capacity (kg h^{-1}) were calculated and the results were presented.

Grading performance of oscillatory type onion size grader :

The grading performance of motorized Oscillatory Type Onion Size Grader for Satara Garva variety is presented in Table 1. The average percentage of feed collected in each outlet: 30-40, 40-60 and >60 mm was found to be 36.80, 18.07 and 25.40%, respectively. About 19.74% of onion bulbs were ungraded due to clogging. The overall grading effectiveness of oscillatory grader was 0.188. The average capacity of the grader for Satara Garva was 365.9 kg h^{-1} and the mean bulb damage during grading observed to be 10.54%.

The performance of the Oscillatory Type Onion Size Grader for Arka Kalyan onion variety is presented in Table 1. The percentage of feed collected in the outlet: 30-40, 40-60 and >60 mm for the Arka Kalyan was 11.68, 81.17 and 4.61%, respectively. About 2.53% of onion bulbs were ungraded due to clogging. The overall grading

effectiveness of oscillatory grader for Arka Kalyan was 0.538. The average capacity of the grader was observed to be 1538 kg h^{-1} and the average bulb damage in the grader on weight basis was recorded as 10.74%. Perhaps due to high operating speed of the machine, onion bulbs bounced on the grading unit frequently which caused more impact damage to onion bulbs and also resulted in removal of top dried layer. High percentage of bulb

Table 1: Performance of oscillatory type onion size grader for *Satara Garva* and *Arkha Kalyan* onion variety

Trial	% of feed ungraded (clogged)	Overall Effectiveness, $?_e = ?_1 \times ?_2 \times ?_3$	Overall Capacity, kg h^{-1}	Bulb Damage, %	Trial	% of feed ungraded (clogged)	Overall Effectiveness, $?_e = ?_1 \times ?_2 \times ?_3$	Overall Capacity, kg h^{-1}	Bulb Damage, %
1.	14.00	0.206	344	6.82	1.	3.29	0.476	1446	9.80
2.	18.57	0.206	390	8.91	2.	3.21	0.458	1607	8.23
3.	25.44	0.146	346	7.66	3.	2.11	0.634	1522	10.25
4.	20.73	0.204	386	9.42	4.	2.33	0.571	1446	10.50
5.	21.49	0.188	387	11.52	5.	2.23	0.467	1808	12.50
6.	21.32	0.148	362	13.46	6.	2.03	0.582	1607	10.25
7.	16.60	0.219	345	15.97	7.	2.52	0.581	1523	13.66
Mean	19.74	0.188	365.89	10.54	Mean	2.53	0.538	1565.67	10.74
Standard Deviation		0.03	21.39	3.29	Standard Deviation		0.07	125.37	1.80
CV %		15.73	5.84	31.24	CV %		13.01	8.01	16.72

Table 2: Performance of roller type onion size grader for *Satara Garva* and *Arkha Kalyan* onion variety

Trial	% of feed ungraded (clogged)	Overall Effectiveness, $?_e = ?_1 \times ?_2 \times ?_3$	Overall Capacity, kg h^{-1}	Bulb Damage, %	Trial	% of feed ungraded (clogged)	Overall Effectiveness, $?_e = ?_1 \times ?_2 \times ?_3$	Overall Capacity, kg h^{-1}	Bulb Damage, %
1	11.84	0.577	276	30.67	1	6.44	0.609	344	30.44
2	8.38	0.574	259	40.11	2	8.53	0.579	370	39.15
3	10.13	0.598	232	45.54	3	17.01	0.620	326	44.26
4	11.33	0.539	254	51.23	4	9.78	0.546	376	45.84
5	12.75	0.482	265	53.56	5	7.31	0.614	387	51.66
6	10.18	0.600	268	60.64	6	9.54	0.611	342	55.31
7	13.45	0.489	254	65.98	7	8.90	0.565	345	58.97
Mean	11.15	0.551	258	49.68	Mean	9.64	0.592	356	46.52
Standard Deviation		0.05	14.04	12.06	Standard Deviation		0.03	22.05	9.81
CV %		8.93	5.44	24.29	CV %		4.83	6.20	21.08

Table 3: Performance of manual operated sieve type onion size grader for *Satara Garva and Arka Kalyan* onion variety

Trial	% of feed ungraded (clogged)	Overall Effectiveness, $?_e = ?_1 \times ?_2 \times ?_3$	Overall Capacity, kg h^{-1}	Bulb Damage, %	Trial	% of feed ungraded (clogged)	Overall Effectiveness, $?_e = ?_1 \times ?_2 \times ?_3$	Overall Capacity, kg h^{-1}	Bulb Damage, %
1	5.43	0.703	648	8.55	1	6.00	0.680	416	5.12
2	4.61	0.747	463	9.12	2	5.32	0.613	392	4.33
3	4.80	0.691	704	11.22	3	6.60	0.535	444	6.73
4	7.41	0.634	476	13.2	4	5.68	0.485	533	5.96
5	4.50	0.719	437	7.99	5	6.46	0.603	493	6.82
6	6.84	0.686	506	8.53	6	4.22	0.612	555	5.39
7	3.70	0.708	540	9.11	7	5.04	0.555	533	5.88
Mean	5.33	0.698	539	9.67	Mean	5.62	0.583	481	5.75
Standard Deviation		0.03	100.29	1.86	StdDv		0.06	63.96	0.89
CV %		4.97	18.60	19.27	CV %		10.91	13.30	15.41

damage may not be acceptable to farmers. It may not be proper to compare onion size graders of different design when not tested at similar conditions. Still it is not out of place to conclude that the oscillatory type onion size grader that is being discussed here is not best suited for all major onion varieties grown in Karnataka especially the popular Satara Garva variety. With some adjustments in operational parameters, it can be employed for grading Arka Kalyan variety of onion.

Grading performance of roller type onion size grader :

The grading performance of Roller Type Onion Size Grader for Satara Garva variety is presented in Table 2. The average percentage of feed collected in each outlet: <30, 30-40 and 40-50 mm was found to be 3.72, 37.80 and 47.34%, respectively. About 11.15% of onion bulbs were ungraded due to clogging. The overall grading effectiveness of roller type grader was 0.551. The average capacity of the grader for Satara Garva was 258 kg h^{-1} and the mean bulb damage during grading observed to be 49.68%.

The performance of the Roller Type Onion Size Grader for Arka Kalyan onion variety is presented in Table 2. The percentage of feed collected in the outlet: <30, 30-40 and 40-50 mm for the Arka Kalyan was 11.39, 2.17 and 55.79%, respectively. About 9.64% of onion bulbs were ungraded due to clogging. The overall grading effectiveness of roller type grader for Arka Kalyan was 0.592. The average capacity of the grader was observed to be 356 kg h^{-1} and the average bulb damage in the grader on weight basis was recorded as 46.52%.

The rotating motion of the rollers cause the forward movement of onion bulb at the same time it causes bulb skin damage of more than 3 mm depth. Because of this reason the bulb damage in the grader for Satara Garva variety was high.

Grading performance of manual operated sieve type onion size grader :

The grading performance of manual operated Sieve Type Onion Size Grader for Satara Garva variety is presented in Table 3. The average percentage of feed collected in each outlet: <30, 30-50 and 50-70 mm was found to be 33.12, 38.29 and 53.26%, respectively. About 5.33% of onion bulbs were ungraded due to clogging. The overall grading effectiveness of sieve type grader was 0.698. The average capacity of the grader for Satara Garva was 510 kg h^{-1} and the mean bulb damage during grading observed to be 9.67%.

The performance of the manual operated Sieve Type Onion Size Grader for Arka Kalyan onion variety is presented in Table 3. The percentage of feed collected in the outlet: <30, 30-50 and 50-70 mm for the Arka Kalyan was 16.88, 65.56 and 11.94%, respectively. About 5.62% of onion bulbs were ungraded due to clogging.

The overall grading effectiveness of sieve type grader for Arka Kalyan was 0.583.

The average capacity of the grader was observed to be 481 kg h^{-1} and the average bulb damage in the grader on weight basis was recorded as 5.75%.

The results indicated that this grader is reasonably good in terms of grading effectiveness. Since, it is a sieve type, clogging and blending sieve boles was frequently observed reducing the capacity of the unit. The sieve type grader also needed more man power to operate. If the feed rate of the grader is high, the effectiveness decreased due to improper spreading of bulbs on the grading unit.

Conclusion :

The grading performance results indicated that of both oscillatory type and motorized roller type onion size grader was unsuitable for onion grading and bulb damage during grading was unacceptably high. The performance of manual operated sieve type onion size grader was found to be reasonably good for both selected varieties *viz.*, Satara Garva and Arka Kalyan, but it needs more human energy to oscillate the machine.

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