Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-6: 2907-2914

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7692 Special Issue-6 pp. 2907-2914
Journal homepage: http://www.ijcmas.com

Original Research Article

Design and Development of On-Farm Onion Grader

S. K. Karthik[1*], V. Palanimuthu[2] and Satishkumar[1]

[1]UAS, GKVK, Bangalore, Karnataka, India
[2]AICRP on PHET, UAS, GKVK, Bangalore – 65, Karnataka, India
**Corresponding author*

Keywords

Onion varieties, onion grader, feed rate and slope

A B S T R A C T

India has exporting fresh fruit and vegetables for several decades. However, export promotional activities have received more attention in recent years. Grading of fruits and vegetables, is one of the most important operations since it adds value to the product and gives better economic gain to the producer. Grading of onions done on the basis of size and shape is important for marketing uniform high quality produce. Grading by human eye judgment is quite difficult. It takes long time to do the grading process and hence labour charges will be more. A manually operated prototype tubular on-farm onion grader was developed using locally available material and tested for its grading performance for the three onion genotypes namely, SataraGarva, ArkaKalyan and Bangalore Rose onion. Provision was made for slope and clearance adjustment. The effects of grading slope (13°, 15°& 18°) and feed rate (300, 450 and 600 kg/h) on grading effectiveness, bulb damage and grading capacity of the developed grader were studied. For optimum grading performance in the developed grader, 13°grading slope and 300 kg/h feed rate were found to be optimum for tested onion varieties. The cost of grading onion for the developed grader was Rs. 130 per tone and the Cost: Benefit Ratio was worked out to be 1.00: 7.69. The developed prototype was found to be good for on-farm grading of selected onion genotypes.

Introduction

Onion (*Allium cepa*, L.), a plant species of the family *Alliaceae* with food and medical properties, contains many essential vitamins and mineral materials. 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 (Karthik *et al.*, 2016). Grading plays a major role in the food processing industries. The purpose of grading onion is to conform to 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. Manual grading is an expensive and time consuming process and even the operation is affected due to non-availability of labours during peak seasons (Narvankar and Jha, 2005). Huge amount of energy is invested in this operation and the produce is handled for number of times in this operation which results in increasing of wastage and may decrease marketing value (Gayatri *et al.*, 2016).

Mechanical grading gains more importance in large scale marketing to fetch higher prices and also India have good mechanical grading equipment based on various criteria like size, shape, weight, colour (Ukey *et al.*, 2010).

In India, the erratic power supply and the low-level of technology are the factors that may hinder the adoption of the emerging technologies in agricultural products handling. Unless these factors are addressed, the application of automated sorting of agricultural materials in India will remain an illusion. Proper technology has not yet been developed in our country to compete in the international market especially when world has been turned into a global village and World Trade Organization (WTO) has specified its standards to meet the international trade contracts (Borkar *et al.*, 2013).

Onion graders developed, fabricated and marketed in India are of screen or roller type having the capacity of 10 to 12 t/h 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. Hence, the need of an efficient small capacity onion grader was felt mainly to grade the onion bulbs at farm level.Considering the above facts concerning the importance of on-farm grading, the onion grader developed at the level of farmer (Dabhi and Patel, 2010).

Materials and Methods

Development of on-farm onion grader

A simple, manually operated machine was designed and developed for grading onion bulbs. The grader was fabricated in the Department of Agricultural Engineering, University of Agricultural Science, Gandhi KrishiVigyan Kendra, Bengaluru. The following factors were considered while developing the grader: (a) Suitability of machine for the grading of onion bulbs in the fields. (b) Ease of operation and maintenance. (c) Energy efficient and low cost of operation. (d) Minimum damage to bulbs.

The developed prototype On-farm Onion Grader Unit (Fig.1) consisted of (i) Feed hopper, (ii) Tubular bulb grading unit (3 to 4 stages of grading), (iii) Collection unit, (iv) Mainframe and (v) Manual oscillation system.

Feed hopper

The horizontal section of feed hopper was trapezoidal in shape and was fabricated out of mild steel sheet of 1 mm thickness. The hopper was inclined for smooth delivery of bulbs over the tubular grading system and the outlet end of hopper was kept at the center between the first and sixth pipe. The wider end of hopper was 720 mm and the other end was 500 mm wide. The length of hopper was kept at 463 mm. To avoid bulbs jumping out of the hopper, 130 mm height side wall made up of a 1 mm thickness mild steel sheet was provided. The feed hopper was mounted on the main frame to feed the onion bulbs on to the grading unit.

Bulb grading unit (PVC pipes)

The bulb grading unit was made up of six numbers of diverging PVC pipes of 50 mm diameter and length 900 mm. To adjust space between the pipes to grade the bulbs as per the requirement, a 6 mm diameter long threaded bolt (650 mm length) was passed through all pipes at the top end. To avoid change in the space between the pipes during grading, each pipe is secured on the bolt on both sides using nuts. On the lower end, the pipes were fixed on a 6 mm thick flat of 700 mm length with nut and bolt. The center to center distance between the pipes was kept as 110 mm at the lower end. The pipes were arranged in series on main frame with enlarging gap between adjacent pipes from upper end to lower end in order to grade onion into different grades. In order to avoid the onion to flow over the pipes and also to give the direction to bulbs to flow down between the gaps of pipes, rectangular polythene flats of 210 mm length and 3 mm thickness was fixed on four inner pipes at the top end of grading unit.

Manual oscillation system

To help easy flow of onion bulbs on the grading unit (pipes), the tubular grading unit was vertically oscillated up and down at the lower end using a manual oscillation system. This system consisted of a long (930 mm) 12 mm diameter shaft having a rotating handle at one end. The shaft was mounted on two ball bearings fastened on the main frame. Two cams (60 mm dia. pipe pieces) were welded on the shaft which pushes the matching members (used ball bearings) fixed on the bulb grading unit up and down. When the shaft was rotated manually, for each revolution, the entire grading unit was oscillated up and own once by the cam arrangement. This helped of onion bulbs move down the grading unit smoothly and also helping the bulbs to fall down without blocking the grading space. The rotational speed was varied between 80 to 100 rpm for grading and the amplitude of oscillation was 60 mm.

Collection unit

The onion bulb collection unit was basically comprised of four parabolic shaped linen troughs. These linen flexible collection channels that slope towards one end to facilitate collection of graded onion bulbs were actually hung from the main frame just below the tubular grading pipes. Each trough collected on grade of onion bulbs dropping from above through the gap between pipes. The flexible linen material was chosen mainly to reduce injury to falling onion bulbs.

Main frame

The feeding hopper unit, tubular grading unit, oscillation unit and the collection unit, all are assembled on a structural frame. The main frame of the machine was fabricated out of M.S. angle section of 40x40x6 mm. The overall dimensions of the frame were: top upper side width - 500 mm and bottom lower side width - 720 mm, length 910 mm and height 900 mm. In order to vary the slope of the grading unit i.e., the downward inclination, the main frame was raised or lowered on the upper side (feeding end).

Grading operation

During each trial, 10 kg of bulbs were fed to the grader. Before grading operation, the labours were trained to uniformly rotate the oscillating system at about 80-100 rpm. Further, the operators were trained to uniformly feed the bulbs to the grader at the selected feed rates. Initially the bulk onion bulbs of each selected variety were graded manually into four desired grades as: <40, 40-50, 50-60 and >60 mm for SataraGarva and ArkaKalyan onion varieties and <30 mm and >30 mm for Bangalore Rose Onion, 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:

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

$$\begin{bmatrix} \text{Target onion} \\ \text{size collected (\%)} \end{bmatrix} = \frac{\text{Weight of target size collected in the outlet (kg)}}{\text{Weight of onion in the oulet (kg)}} \times 100$$

Grading effectiveness

The grading effectiveness of on-farm onion grader was estimated by multiplying all outlet effectiveness that can be calculated by using following relation.

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

$$\text{Overall grading effectiveness of grader, } \varepsilon = \varepsilon_1 \times \varepsilon_2 \times \varepsilon_3$$

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:

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

Results and Discussion

Performance evaluation of developed prototype On-Farm onion grader and optimization of operational parameters

Grading performance of on-farm onion grader for *SataraGarva* variety

The grading performance of the developed prototype on-farm onion grader is presented in Table 1 as well as in Fig 5.1. As the feed rate increased the effectiveness of the grader decreased. The effectiveness of the grader was found to be decreasing with increase in slope and also at higher feed rate of 600 kg/h. As the feed rate increased, the bulb damage in the grader also increased. The damage of bulbs in the grader for SataraGarva variety was found to be less at lower grading slope of 13^o and lower feed rate of 300 kg/h. As the feed rate increased, the grading capacity also increased. The grading capacity of on-farm onion grader for SataraGarva variety was found to be less at lower grading slope of 13^o and it was found to be non-significant with respect to grading slope.

Increase in grading slope and feed rate, generally increase the velocity of downward movement of bulbs along the tubular pipes giving relatively lesser opportunity for bulbs to drop down through the space between two pipes and therefore, the grading effectiveness decreased. At the same time, the grading capacity increased at the cost of more bulb damage as well effectiveness.

Considering all the three grading attributes, 13^{o} grading slope and 300 kg/h feed rate, was selected to be optimum for SataraGarva variety of onion in the developed on-farm onion grader.

Grading performance of on-farm onion grader for *ArkaKalyan* variety

The grading performance of developed on-farm onion grader for ArkaKalyan variety of onion has been presented in Table 2 and in Fig 5.2. As the feed rate increased the effectiveness of the grader for ArkaKalyan genotype decreased.

The effectiveness of the grader for ArkaKalyan variety was found to be good at grader slope of 13^{o} and at feed rate of 300 kg/h when compared to other combination of slope and feed rates. As the feed rates increased the bulb damage in the grader also increased.

The bulb damage in the grader was found to be less at lower grading slope (13^{o}) and low feed rate (300 k/h). As the feed rate increased, the grading capacity also increased.

The grading capacity of the grader for ArkaKalyan variety was found to be high at 18^{o} slopes and 600 kg/h feed rate when compare to other combinations of slope and feed rate.

Narvankar and Singh (2005) have also reported similar observation for grading fruits lemon, aonla & ber. Shahir, S and Thirupathi, V. (2009) also reported that the skinning damage by divergent roller grader for potato 9^{o} slope and 480 kg/h feed rate was 2.5% and 3.0% at 9^{o}.

Considering the grading effectiveness of 0.946, lower bulb damage of 1.423% and reasonably good grading capacity of 280 kg/h (for manual grader), the grading slope of 13^{o} and feed rate of 300 kg/h was reckoned to be optimum.

Grading performance of on-farm onion grader for *Bangalore Rose* variety

The grading performance of the developed on-farm onion grader for various operational parameters like grading slope and feed rate with Bangalore Rose Onion has been presented in Table 3 and also in Fig 5.3. As the feed rate increased the effectiveness of the grader decreased. The effectiveness of the grader for Bangalore Rose variety was found to be highest for 13^{o} slope and 300 kg/h feed rate when compared to other combinations of slope and feed rate. As the feed rate increased the bulb damage in the grader increased. The damage of bulbs in the grader for Bangalore Rose variety was found to be low at 13^{o} slopes and 300 kg/h feed rate, when compare to other combinations of slope and feed rate. As the feed rate increased, the grading capacity also increased.

The grading capacity of the grader for Bangalore Rose variety was found to be maximum for the feed rate of 600 kg/h and it was found to be non-significant with respect to feed rate.

The grading effectiveness of the grader was exceptionally good at lower feed rate of 300 kg/h for all grading slopes since the opportunity time for separation will be always high for lower feed rates and lower grading slopes. It could be seen that onion bulb damage with lower feed rate of 300 kg/h was very low at all grading slopes. The grading capacity attained was 285 kg/h for 13^{o} slope.

Table.1 Effect of grading slope and feed rate on effectiveness, bulb damage and capacity of on-farm onion grader for *SataraGarva* variety

Onion variety	**SataraGarva**								
Grading slope	**Slope 13^o(S_1)**			**Slope 15^o (S_2)**			**Slope 18^o (S_3)**		
Feed rate (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)
300 kg/h (f_1)	0.899	1.42	268	0.883	3.10	285	0.850	6.49	272
450 kg/h (f_2)	0.893	3.10	355	0.862	5.08	375	0.776	6.77	358
600 kg/h (f_3)	0.594	4.23	531	0.775	7.05	520	0.596	9.03	512

Table.2 Effect of grading slope and feed rate on effectiveness, bulb damage and capacity of on-farm onion grader for *ArkaKalyan* variety

Onion variety	**ArkaKalyan**								
Grading slope	**Slope 13^o(S_1)**			**Slope 15^o (S_2)**			**Slope 18^o (S_3)**		
Feed rate (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)
300 kg/h (f_1)	0.946	1.42	280	0.929	1.54	278	0.886	2.42	281
450 kg/h (f_2)	0.884	2.42	358	0.903	2.20	356	0.836	3.96	375
600 kg/h (f_3)	0.800	5.49	520	0.805	5.71	549	0.756	6.95	552

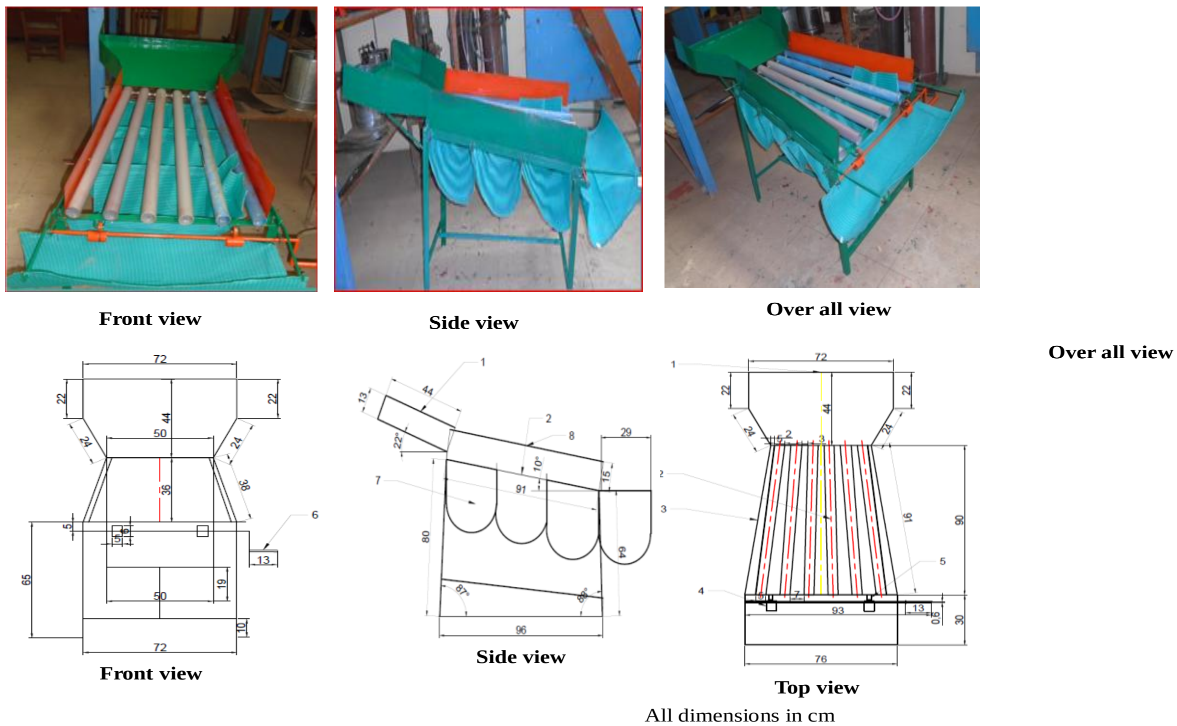
Table.3 Effect of grading slope and feed rate on effectiveness, bulb damage and capacity of on-farm onion grader for *Bangalore Rose* variety

Onion variety	**Bangalore Rose**								
Grading slope	**Slope 13^o(S_1)**			**Slope 15^o (S_2)**			**Slope 18^o (S_3)**		
Feed rate (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)	Grading Effectiveness	Bulb damage (%)	Capacity (kg/h)
300 kg/h (f_1)	0.948	0.32	285	0.917	0.40	285	0.919	0.40	284
450 kg/h (f_2)	0.899	1.24	374	0.892	1.36	369	0.850	2.44	372
600 kg/h (f_3)	0.869	1.76	534	0.833	2.24	524	0.708	3.68	515

Table.4 Grader performance at optimum operational parameters

Parameter	**SataraGarva** Slope – 13^0 Feed rate – 300 kg/h	**ArkaKalyan** Slope – 13^0 Feed rate – 300 kg/h	**Bangalore Rose** Slope – 13^0 Feed rate – 300kg/h
Grading Effectiveness Overall (ε)	0.899	0.946	0.948
For Grade – 1 (ε_1)	0.930	0.903	0.882
For Grade – 2 (ε_2)	0.855	0.906	0.997
For Grade – 3 (ε_2)	0.993	0.992	-
Grading Capacity, kg/h	268	280	285
Bulb Damage, %	1.423	1.425	0.327

Fig.1 Developed prototype on-farm onion grader (Hopper or Feeding unit 2.Grading unit 3. Frame 4. Cam 5. Ball bearing 6. Handle 7.Collection unit)



Considering all the three grading attributes, the grading slope of 13^o and feed rate of 300 kg/h was considered to be optimum for Bangalore Rose Onion variety in the developed grader. Through a higher capacity of could be obtained at 450 kg/h feed rate accepting slightly higher (still low value @ 1.24%) percentage of bulb damage, Bangalore Rose onion being an export oriented commodity, lower bulb damage and perfect grading is desirable. The variation in capacity of sapota fruit grader from 1152 kg/h to 1800 kg/h with change in roller speed was reported by Patil and Patil (2002)

Optimum operational parameters for best grader performance

From the performance evaluation results of developed on-farm onion grader with selected three varieties of onion like SataraGarva, ArkaKalyan and Bangalore Rose Onion. It was observed for high grading effectiveness, lower bulb damage and reasonably good grader capacity could be obtained at 13^o grading slope and 300 kg/h feed rate (Table.4) Hence, this slope and feed rate is recommended for all the three tested onion varieties.

Cost economics

The cost economics of the grading with developed prototype on-farm onion grader was worked out by taking into account the fixed and variable costs. The cost of grading onion was computed to be Rs. 130 per tonne and the Cost: Benefit Ratio was estimated to be ₹ 1.00: 7.69.

The cost of grading onion in the developed on-farm onion grader is quite low. It is easy to fabricate with locally available material at low cost and the operation is simple demanding practically little skill. Hence, the grader can be recommended for on-farm grading of onion in case of marginal and small holdings.

A manually operated on-farm multi varieties onion grader has been designed, developed and evaluated for its grading effectiveness, bulb damage and capacity. The developed, prototype manually operated on-farm onion grader is well suited for grading different varieties of onion. The grading effectiveness, bulb damage and grading capacity of developed on-farm onion grader for selected three onion varieties were found to be in the range of 0.899 to 0.948, 0.327 to 1.425% and 268 to 285 kg/h. From three grading slopes (13^o, 15^o& 18^o) and three feed rates (300, 450 & 600 kg/h) tested, 13^o slope and 300 kg/h feed rate were found to be optimum operational parameters. The cost of grading one tonne of onion was ₹ 130 and the Cost: Benefit Ratio was worked out to be ₹ 1.00: 7.69. Grading is crucial because of its potential to regain and increase export earnings.

The feature line of work could be done by evaluating grading effectiveness and bulb damage with increasing the length of grading unit and changing power source from manual to electrical motor operated one. Improvisation made in feeding mechanism from manual to mechanical may be attempted. Machine may be evaluated for grading other fruits & vegetables.

References

Borkar, P.A., Murumkar, R.P. and Rajput, M.R., 2013, Testing the performance of spherical fruit grader for apple and pomegranate. *Internat. J. Sci. Environ. & Tech.*, 2(5): 1059-1071.

Dabhi, M. N. and Patel, N. C., 2010, Studies on forced air ventilated storage of onion. *Lamber Academic Publishing*, Germany.

Gayathri, G., Harshanjali, K.V., Rupavathi, K., Vijay Kumar, D., Senthil Kumaran, G., Carolin Rathina Kumari, A. and Ramana, M.V., 2016, Design, development and evaluation of a manually operated onion grader for Rose onion, *Internat*. *J. of Agri. Engg*, 2(9): 121-129.

Karthik, S.K., Satishkumar, and Palanimuttu V., 2016, Engineering Properties of Some Indian Onion Cultivars.*Internat. J. of Agri. Sci.*, 29(8), 1613-1617.

Narvankar, D. S., Jha,S. K.and Singh,A, 2005, Development of rotating screen grader for selected orchard.*J. of Agri. Engg*, 42 (4): 60-64.

Narvankar, D.S.and Singh, A., 2005, Development of rotating screen grader for selected orchard.*J. of Agri. Engg.*,42(4): 73-78.

Patil, V. B. and Patil, J. S., 2002, Design, development and performance testing of grader for sapota fruits. *B. Tech. Thesis*, MPKV, Rahuri.

Shahir, S. and Thirupathi, V., 2009, Performance evaluation of a divergent roller grader for selected vegetables.*Agriculture Mechanization in Asia*, 40(2): 60-62.

Ukey, P. D. and Unde, P., 2010, Design, development and performance evaluation of sapota fruit grader. *Internat*. *J. of Agri. Engg.*, 3(1): 35-39.