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Design, development and performance evaluation of garlic bulb (*Allium sativum*) breaker for planting material production

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ABSTRACT

Garlic (*Allium sativum* L.) is one of the important bulb crops grown and used as a spice in culinary ingredient as it adds to the taste and flavour in a wide range of food preparations. It also has medicinal properties. Garlic is propagated by single clove. Conventionally, garlic cloves are separated by rubbing the bulb between palms, against jute bags or by beating with a wooden stick. These methods are very laborious and time consuming. Hence, a garlic bulb breaker to break and separate cloves from the whole garlic bulb was designed and developed. The garlic bulb breaker consisted of feeding chute, rubber padded rollers (two stages), blower, outlets for cloves and skins, main frame, power and power transmission system. The garlic bulb breaker was evaluated with three types of rubber padding material: plain-plain, button-button and corrugated-corrugated, four clearances between the rollers: 15, 18, 21 and 24 mm and three peripheral speed of rollers: 25.92, 34.56 and 43.2 m/min. Germination experiments were conducted to study the quality of garlic cloves as planting material with the garlic cloves separated by the machine. Highest breaking efficiency of 75% was obtained with corrugated type rubber padding material at an optimum clearance of 18–21 mm clearance between rollers and at 43.2 m/min peripheral speed of rollers. Minimum damage of 0 to 0.7%% and clove loss of 1.08% were observed at optimized parameters. The garlic cloves separated by the developed machine had 100% germination. The breaking capacity of machine was 195 kg/hr. The operating cost of the machine ₹ 0.3/kg against ₹ 2.25/kg by manual clove separation.

Key words: Garlic, Garlic bulb breaker, Garlic clove separation, Planting material

Garlic (*Allium sativum* L.) is one of the important bulb crops grown and used as a spice or condiment throughout India. India produces about 3.5% of world's total garlic production and ranked second after China. In India, garlic is grown in an area of 239 thousand ha with the production of 1.22 million tonnes and productivity is 5.69 tonnes/ha. Area under garlic has increased by 60% during the last 10 years (NHB 2013). Garlic is propagated by single clove. Depending on the variety, seed rate ranges from 500 to 750 kg/ha. The total clove requirement for 239 thousand ha of land is 120 thousand to 180 thousand tonnes/year. Planting material is the basic and crucial input in agricultural production. Crop yield is directly dependent on seedling emergence and establishment. Therefore, availability planting material during the planting season in very important to meet the increased demand. Garlic bulb is a compound bulb and has 6-26 cloves in each compound bulb.

Garlic bulbs are broken and loosened into garlic cloves. Conventionally, garlic cloves are separated by rubbing the bulb between palms, against jute bags or by beating with a wooden stick. These methods are very laborious and time consuming (Mudgal *et al.* 1998). Through improved planting material production, both yield and quality can be improved, to fetch higher prices in the market. Considering the large quantities of planting material requirement, a mechanical garlic bulb breaker was developed and its performance was evaluated.

MATERIALS AND METHODS

Conventionally the separation of garlic cloves from garlic compound bulb is carried out by shearing as well impact forces. Using this principle, the garlic bulb breaker was developed. The front and side views of garlic bulb breaker are given Fig 1. The garlic bulb breaker consisted of feed hopper, cloves separating rollers (two stages), blower, outlets for separated garlic cloves and skin, root and stem fractions, power and power transmission systems.

The rectangular shape feeding chute of 820 mm × 560 mm was provided above the first stage rollers for feeding the garlic bulbs. Two rollers of each 500 mm length, 275 mm diameter and 10 mm thickness were selected for achieving higher capacity (Mandhar *et al.* 2005, Trinath *et al*. 2013). The rollers were made to rotate opposite direction

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to each other and also at different speeds to achieve a shearing force for separation of cloves. The top surface of the rollers were covered by rubber padding material to reduce the damage to the cloves. Experiments were conducted to optimize the clearance between the first stage rollers and peripheral speed of rollers at different rubber padding materials. Three types of rubber padding material, viz. plain, button and corrugated type were used during this study. Based on the mean geometric diameter of bulb (45.69±0.85 mm), the clearance between the rollers varied as 15, 18, 21 and 24 mm and the different peripheral speeds were 25.92, 34.56 and 43.2 m/min. Based on the optimum separation efficiency, minimum clove damage and breaking capacity, the padding material, clearance between the first stage rollers and peripheral speed of rollers were selected.

As the second stage rollers had to pass singles cloves, clumps of cloves and light weight fractions, the diameter was selected as 125 mm and clearance between the rollers was maintained as 10 to 12 mm. The second stage roller was covered with the selected rubber padding based on the experiments carried out for first stage rollers. A straight blade type centrifugal aspirator with a blade of 62 mm width and 335 mm diameter was selected for cleaning the material passing through second stage rollers (Sahay and Singh 1994). The fractions other than cloves, i.e skins, roots and stems were separated by the blower and collected in the respective out lets. A three phase, 1.5 kW, 1440 rpm AC reduction geared motor (60 rpm) was used as prime mover for different units of machine. The power was transmitted by belt and pulley arrangements to the roller and blower.

While conducting the experiments to optimize type of padding material, clearance between the rollers and peripheral speed of rollers, first stage rollers only were mounted. The second stage roller and blower were fitted during the performance evaluation of the garlic bulb breaker. Well matured and healthy garlic bulbs were procured from the local market. A sample of 500 g was used for different trials. The compound bulbs were fed into the first rollers through the feeding chute. The time taken to completely feed the garlic bulbs was noted down. The material from both the outlet was collected and separated into different fractions (viz. single cloves, clumps of cloves, damaged cloves and light weight fractions (i.e. skin, root and stem). Each trial was replicated three times. The standard procedure was used to determine the separation efficiency, % clove damage and capacity. Ten single cloves from each trail was selected and planted in pots to study the treatment effects on germination of garlic clove. Each treatment had three replications.

The first and second stage rollers were covered with the selected padding material. The clearance between the first stage rollers was adjusted to the selected clearance and operated at the selected peripheral speed. The blower was mounted. The performance of garlic bulb breaker was evaluated. A sample of 500 g of garlic bulbs were fed through the feed hopper continuously. The time taken to completely feed the garlic bulbs was noted down. The material from both the outlet was collected and separated into different fractions (viz. single cloves, clumps of cloves, % clumps of cloves, damaged cloves and light weight fractions (i.e skin, root and stem). Each trial was replicated three times. The standard procedure was used to determine the performance parameters, viz. separation efficiency, % clumps of cloves, % damaged clove, % cloves collected in husk outlet, capacity and clove germination.

RESULTS AND DISCUSSION

The garlic bulb breaker with three different types of rubber padding materials was evaluated at four clearances between the rollers of 15, 18, 21 and 24 mm and three peripheral speed of rollers of 25.92, 34.56 and 43.2 m/min. The performance of parameters of the garlic bulb breaker as separation efficiency, % clumps of cloves, % damaged cloves, capacity and % germination were estimated. The results were analysed using the statistical package "AGRES" and are presented in Table 1, 2, 3 and 4 respectively.

Separation efficiency

From Table 1, it was inferred that the type of padding material and clearance between the rollers had significant effect and the peripheral speed of rollers did not have effect on the clove separation efficiency. The maximum clove separation efficiency of 55. 56% was obtained with corrugated type padding material at 18 mm clearance between rollers. It was also inferred that the rollers padded with corrugated padding material and fitted at a clearance of 18 mm had highest clove separation efficiency and were on par at all three roller peripheral speeds of 25.92, 34.56 and 43.2 m/min. As maximum separation efficiency of about 56% only could be obtained, a second stage roller was mounted below the existing rollers. The width and thickness

Fig 1 Motorised garlic bulb breaker

Table 1 Effect of type padding material, clearance between the rollers and peripheral speed of the rollers on single clove separation efficiency

Type of padding material	Clearance between the rollers (mm)	Peripheral speed (m/min)		
		25.92	34.56	43.2
Plain rubber material	15	23.35	32.02	27.28
	18	29.18	28.49	25.11
	21	28.02	20.28	20.68
	24	20.03	19.47	13.80
Buttoned rubber material	15	34.26	35.07	31.89
	18	28.36	30.74	28.17
	21	27.37	27.71	29.88
	24	17.04	22.69	26.18
Corrugated rubber material	15	46.53	39.63	42.92
	18	50.73	55.56	47.24
	21	44.79	44.18	40.83
	24	37.42	41.87	46.49
	F value	*SEM*	*CD*	
P	**	1.02	4.68	
C	**	1.18	5.40	
S	NS	1.02		
PC	NS	2.04		
CS	NS	2.05		
PS	NS	1.77		
PCS	NS	3.54		

Table 2 Effect of type padding material, clearance between the rollers and peripheral speed of the rollers on % clumps of cloves

Type of padding material	Clearance between the rollers (mm)	Peripheral speed (m/min)		
		25.92	34.56	43.2
Plain rubber material	15	39.63	40.20	51.15
	18	57.28	54.88	64.42
	21	63.78	73.97	65.35
	24	73.02	78.26	84.09
Buttoned rubber material	15	45.77	58.47	62.33
	18	62.3	57.62	62.87
	21	64.98	98.90	67.20
	24	78.70	71.87	71.53
Corrugated rubber material	15	49.22	57.16	55.37
	18	49.27	43.73	52.61
	21	53.85	48.41	66.82
	24	62.58	57.42	53.51
	F value	*SEM*	*CD*	
P	**	1.23	5.65	
C	**	1.42	6.52	
S	NS	1.23		
PC	**	2.46	11.30	
CS	NS	2.46		
PS	NS	2.13		
PCS	NS	4.27		

of the cloves were 10.18±0.35 mm and 7.42±0.24 mm, a clearance of 10 mm was provided between the second stage rollers. As the maximum separation efficiency was obtained with corrugated rubber padding material, the second stage rollers were padding with the corrugated rubber padding material.

Per cent clumps of cloves

From Table 2, it was inferred that the type of padding material and clearance between the rollers had significant effect and the peripheral speed of rollers did not have effect on the clove separation efficiency. The plain type padding material at 15 mm clearance and corrugated type padding material at 18 mm clearance had clumps of cloves of 39.63 and 49.27% and were on par.

Per cent damaged cloves

From Table 3, it was inferred that the type of padding material, clearance between the rollers and peripheral speed of rollers had significant% crushed cloves. Minimum % of cloves crushed were minimum with corrugated type rubber padding material and it was at the range of (0–0.7%). This minimum range was obtained at 18, 21 and 24 mm clearances and at 34.56 and 43.2 m/min peripheral speeds of rollers and were on par. Maximum of 37.02% cloves got crushed with plain type rubber padding material at 15 mm clearance and at 25.92 m/min. peripheral speed.

Table 3 Effect of type padding material, clearance between the rollers and peripheral speed of the rollers on per cent damaged cloves

Type of padding material	Clearance between the rollers (mm)	Peripheral speed (m/min)		
		25.92	34.56	43.2
Plain rubber material	15	37.02	27.80	21.57
	18	13.54	16.63	7.14
	21	10.51	9.45	10.27
	24	6.94	2.27	2.10
Buttoned rubber material	15	10.03	6.47	5.77
	18	9.34	11.64	8.81
	21	7.64	3.40	2.92
	24	4.25	5.45	2.28
Corrugated rubber material	15	3.80	2.51	1.70
	18	0.00	0.70	0.15
	21	1.36	7.41	0.74
	24	0.00	0.71	0.00
	F value	*SEM*	*CD*	
P	**	0.65	2.99	
C	**	0.75	3.45	
S	**	0.65	2.99	
PC	**	1.30	5.98	
CS	NS	1.30		
PS	NS	1.13		
PCS	NS	2.26		

Capacity

From Table 4, it was inferred that the type of padding material, clearance between the rollers and peripheral speed of rollers had significant effect on garlic bulb breaking capacity. The highest capacity was obtained with corrugated type rubber padding material and it was in the range of 185–210 kg/hr. This range was at 15, 18 and 21 mm clearances and at 43.2 m/min peripheral speed and were on par. It was also observed that the capacity increased with increase in clearances and peripheral speeds. The plain type padding material had the lowest capacity of 82 kg/hr at 15 mm clearance and at 25.92 m/min. This variation in capacity among the padding materials might be due the characteristics of padding materials. As the corrugated type padding material behaved like a conveyor, it positively carried the garlic bulbs for further separation.

Table 4 Effect of type padding material, clearance between the rollers and peripheral speed of the rollers on garlic bulb breaking capacity

Type of padding material	Clearance between the rollers (mm)	Peripheral speed (m/min)		
		25.92	34.56	43.2
Plain rubber material	15	82.49	104.44	120.68
	18	95.16	120.68	136.08
	21	130.71	143.24	130.71
	24	143.24	153.27	136.08
Buttoned rubber material	15	113.99	119.36	153.27
	18	143.24	170.47	170.47
	21	143.24	130.71	170.47
	24	130.71	153.27	185.51
Corrugated rubber material	15	136.08	153.27	185.51
	18	130.71	178.35	195.55
	21	136.08	153.27	195.55
	24	153.27	175.47	210.59
	F value	*SEM*	*CD*	
P	**	3.02	13.88	
C	**	3.50	16.02	
S	**	3.02	13.88	
PC	NS	6.06		
CS	NS	6.06		
PS	*	5.24	18.11	
PCS	NS	10.50		

Per cent germination

Germination of 100% was observed in all the thirty six treatments. From this, it was clear that the cloves did not have any internal injury due to the impact of rubber padding material while separation.

Performance evaluation of garlic bulb breaker

From the results of the different experiments, it was inferred that corrugated type padding material fitted at 18–21 mm clearance had the maximum single clove separation efficiency of 55.56%. In order to increase the separation efficiency, second stage of rollers were fitted below the first rollers. The performance of the garlic breaker was evaluated. It was observed that the garlic bulb breaker had maximum single clove separation efficiency of 87. 20 and 90.40%, clumps of cloves of 5 and 3%, damaged clove of 0.7 and 0.3%, % cloves collected in husk outlet of 1.96 and 1.08% and bulb breaking capacity of 195 kg/h, at 18 and 21 mm clearances respectively.

a) A motorized garlic bulb breaker with two stages of bulb breaking rollers was developed for separation of single garlic cloves from the compound garlic bulbs for production of planting material.
b) The rollers were padding with three types of rubber padding materials, viz. plain, button and corrugated type. The clove separation efficiency was evaluated at four different clearance as 15, 18, 21 and 24 mm and at three peripheral speeds as 25.92, 34.56 and 43.2 m/min.
c) Corrugated type padding material at 43.2 m/min peripheral speed and at 18 and 21 mm could give single clove separation efficiency of 87. 20 and 90.40%, clumps of cloves of 5 and 3%, clove damage of 0.7 and 0.3, cloves collected in hust outlet of 1.96 and 1.08% and bulb breaking capacity of 195 kg/hr at 18 and 21mm clearances respectively.
d) Cost of operation was ₹ 0.30/kg against ₹ 2.25/kg by manual method of clove separation.

REFERENCES

National Horticulture Board 2013. Indian Horticulture Database Ministry of Agriculture, Government of India, New Delhi.

Mandhar S C, Carolin Rathinakumari A and Senthil Kumaran G. 2005. Design and development of a hand operated garlic bulb breaker and garlic peeler. *Journal of. All India Food Processors Association* **59**: 76–81.

Mudgal V D and Sahay S B. 2009. Development and performance evaluation of a garlic bulb breaker. *Agriculture . Mechanization in Asia, Africa and Latin America* **40**: 32–5.

Sahay K M and Singh K K. 1994. *Unit Operations of Agricultural Processing,* pp 42–54 Vikash Publishing House Pvt. Ltd, New Delhi.