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# Determination of Optimum Seed Detaching Force for the Development of Prototype Threshing Unit for Cumin Seed

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**Cumin is extensively cultivated in the arid and semi arid regions of India. Mechanical properties of cumin play an important role in designing and developing of the threshing and other processing machineries for cumin. Cumin, being a delicate seed crop with hard and thorny stems gets damaged easily, posing problem during processing in conventional threshers. AVANI-111 is a cumin variety sown in *Rabi* season and extensively grown in the state of Rajasthan. The research findings i.e. detaching force required for the development of prototype threshing unit for cumin crop is described in this paper. The test was conducted at 9.01 percent (db) seed moisture level and the result shows no significant effect of seed dimension on seed detaching force. The mean force required for seed detaching was measured to be 0.408± 0.146 N. The results obtained can be effectively utilized for optimal use of the material of construction and power source for prototype development.**

(***Keywords:*** *Cumin, Detaching Force, Plucking, Spices)*

India is one of the major producer and consumer of cumin in the world. Cumin (*Cuminum cyminum* L.) is cultivated mainly in the states of Rajasthan and Gujarat during *rabi* season. These arid regions contribute more than 95 percent of the total cumin production in India. Haryana, West Bengal, Uttar Pradesh, Andhra Pradesh and Punjab also make significant contribution to cumin production in India. Almost 80 percent of the crop cultivated is consumed in India itself.

Mechanical properties of cumin play an important role in designing and developing the threshing and other processing machineries. Developing a thresher for cumin, based on seed separating or detaching force, will lead to decrease in cumin seed losses during its threshing operation.

Force required for threshing cumin crop is different from normal threshers with respect to their structure and operation. Previous studies found that the moisture content of crop and the force orientation are the major factors that affect the force and energy to pick or detach the seeds from the crop (Behroozilar *et al*., 1999). To measure the picking force, direct and indirect methods may be used. In indirect method, a centrifugal or acceleration-related force is imposed to the pods *e.g.,* in chickpea (Khazaei *et al*., 2004). In direct method, the pod by means of a special clamp, which is attached to a force gage axially is been pulled until it is detached from the stem (Mesquita and Hanna, 1995). Bruce *et al*. (2002) used a random impact test, involving controlled agitation of samples of 20 canola siliques to measure their breaking response and fitting model. Khazaei *et al*. (2002) showed that by increasing in pulling out velocity of Pyrethrum flower, required force and consumed energy would be increased. In the present study, picking force of cumin seed was measured on the textural analyzer setup by pulling the seed longitudinally along the axis. The relation between force and time was evaluated to reduce the crop rotation time inside the cylinder and to minimize the power requirement.

## MATERIAL AND METHODS

For the moisture content measurement of cumin plant branches and seeds, 100 g and 25 g samples were taken for branch & seed respectively under ten different groups. The mean of ten samples was considered as an overall all moisture content of cumin seed and branches. The cumin seed samples were dried at $103^{o} \pm 2^{o}$C for 72 h in hot air oven and cumin branch samples at $65^{o} \pm 5^{o}$C for 72 h. After drying the weight was taken. The moisture

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content of cumin seed and branch, was calculated on dry basis using following mathematical formula (ASAE - 1985):

$$M_{db} = \frac{W_w}{W_d} \times 100 \quad (1)$$

Where,

$M_{db}$ = Moisture content on dry basis (%)

$W_1$ = Initial weight of sample, g

$W_w$ = Weight of water $(w_1 - w_d)$, g

$W_d$ = Weight of dry matter, g

The cumin seed detachment force was measured on the texture analyzer setup. The moisture content of the cumin crop was selected as per the threshing time followed traditionally by cumin growers. The length, width and thickness of cumin seed were measured with digital vernier caliper with 0.01 mm accuracy to evaluate the influence of seed dimension in the detaching force. For detachment of cumin seed; the special tool was fixed at holding jaw of texture analyzer and at other end of the tool, a single cumin seed was tied up with the help of small copper wire of diameter 2.053 mm (AWG-12) as shown in Fig. 1. For holding the plant at the bottom, a small holding jaw was used with cushioning. The jaw was fixed on the testing platform of texture analyzer. The initial weight of tool and wire were made to zero and the texture analyzer was set on the auto force, due to which the necessary force required for the plucking was developed by texture analyzer. The details of seed detachment with texture analyzer setup are shown in Fig. 2. For plucking the seed the texture analyzer was set at following setting shown in Table 1.

## RESULTS AND DISCUSSIONS

Results showed that stem moisture content and pulling out force had significant effect on cumin seed detaching force. The mean value obtained showed that, the cumin seeds need varied detaching force. The variation in values is attributed to the difference in morphology and petiole texture properties (Morgan *et al*., 1998). Overall thirty samples were tested for measuring the seed detaching force and the results obtained are presented in table 2.

From the data obtained, it was noticed that the minimum and maximum mean force for cumin seed detachment was in between the range of 0.115 N to 0.634 N. The mean force obtained was 0.408 N $\pm$ 0.146 with respect to mean time 8.17 sec $\pm$ 2.79. No relationship has been observed between the seed spatial dimension and detaching force.

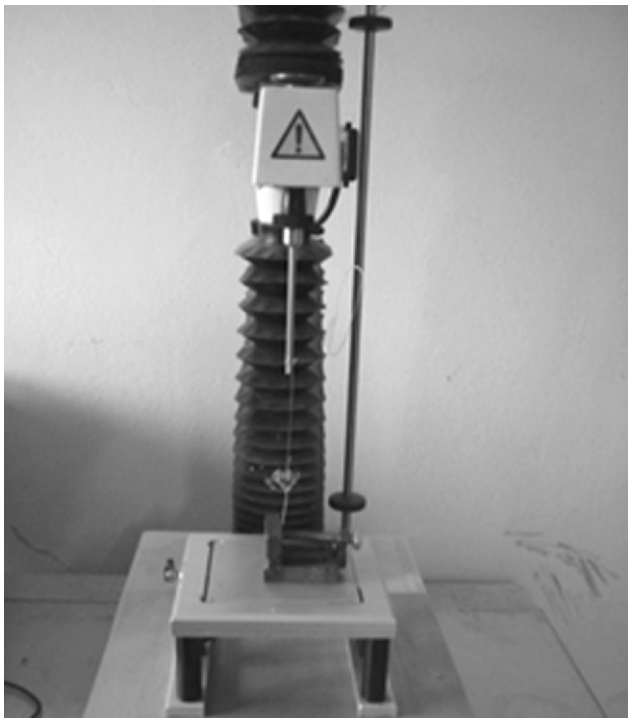

***Fig. 1.*** *Setup for detaching single cumin seed*

***Fig. 2.*** *Force measurement for the cumin*

***Table 1.*** *Texture analyzer setup values for determination of cumin detaching force*

| Caption | Values |
|---|---|
| Test Mode | Tension |
| Pre-test Speed (mm $sec^{-1}$) | 1.00 |
| Test speed (mm $sec^{-1}$) | 2.00 |
| Post-test speed (mm $sec^{-1}$) | 10.00 |
| Target Mode | Distance |
| Distance (mm) | 10 |
| Trigger type | Auto (Force) |
| Trigger force (N) | 0.01 |
| Test Mode | Tension |

***Table 2.*** *Variations in cumin seed detaching force*

| S. No. | L (mm) | W (mm) | T (mm) | Mean seed detaching time (sec) | Mean seed detaching force (N) |
|---|---|---|---|---|---|
| 1 | 4.77 | 1.28 | 1.3 | 7.00 | 0.634 |
| 2 | 5.16 | 1.44 | 1.39 | 9.00 | 0.397 |
| 3 | 4.83 | 1.46 | 1.37 | 6.25 | 0.268 |
| 4 | 4.9 | 1.47 | 1.24 | 6.00 | 0.366 |
| 5 | 5.28 | 1.38 | 1.3 | 6.50 | 0.367 |
| 6 | 4.93 | 1.38 | 1.12 | 10.50 | 0.39 |
| 7 | 5.04 | 1.36 | 1.28 | 2.50 | 0.115 |
| 8 | 5.27 | 1.41 | 1.27 | 11.50 | 0.464 |
| 9 | 4.55 | 1.35 | 1.24 | 4.00 | 0.167 |
| 10 | 5.49 | 1.59 | 1.36 | 9.50 | 0.529 |
| 11 | 5.39 | 1.36 | 1.2 | 8.25 | 0.475 |
| 12 | 5.37 | 1.37 | 1.3 | 11.75 | 0.412 |
| 13 | 4.89 | 1.39 | 1.25 | 10.50 | 0.574 |
| 14 | 5.3 | 1.47 | 1.27 | 10.00 | 0.573 |
| 15 | 5.07 | 1.32 | 0.91 | 9.25 | 0.41 |
| 16 | 5.54 | 1.45 | 1.26 | 10.50 | 0.571 |
| 17 | 5.08 | 1.41 | 1.38 | 4.50 | 0.164 |
| 18 | 4.92 | 1.21 | 1.13 | 9.20 | 0.39 |
| 19 | 5.68 | 1.49 | 1.32 | 10.50 | 0.57 |
| 20 | 4.96 | 1.36 | 1.25 | 10.00 | 0.572 |
| 21 | 5.11 | 1.49 | 1.27 | 11.70 | 0.41 |
| 22 | 4.55 | 1.44 | 1.29 | 8.20 | 0.47 |
| 23 | 4.52 | 1.32 | 1.16 | 9.22 | 0.44 |
| 24 | 4.85 | 1.51 | 1.33 | 11.75 | 0.41 |
| 25 | 5.02 | 1.47 | 1.31 | 10.00 | 0.568 |
| 26 | 4.71 | 1.27 | 1.12 | 8.25 | 0.478 |
| 27 | 5.03 | 1.3 | 1.25 | 2.76 | 0.163 |
| 28 | 4.73 | 1.25 | 1.23 | 2.80 | 0.115 |
| 29 | 4.88 | 1.42 | 1.35 | 6.65 | 0.4 |
| 30 | 4.68 | 1.36 | 1.24 | 6.50 | 0.365 |
| Mean | 5.02 | 1.39 | 1.26 | 8.17 | 0.408 |
| Std. Dev. | 0.30 | 0.09 | 0.10 | 2.79 | 0.146 |

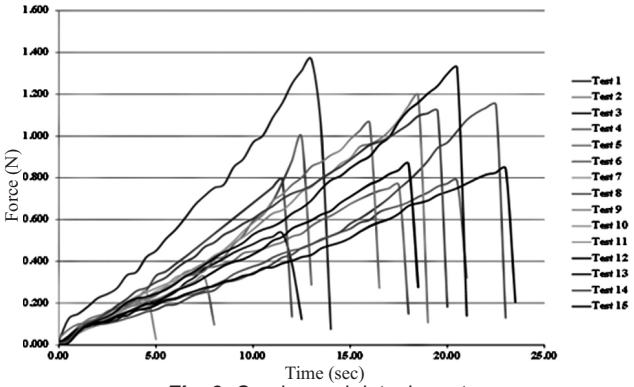


***Fig. 3.*** *Cumin seed detachment*

The graphical representation of seed detaching force with respect to time is presented in figure 3. It was perceived that initially the load moves linearly and reaches to narrowest point before rupturing. Also it was inferred that there is no relation between the seed dimension and detaching force with the confirmation of earlier results for siliqua (Hoseinzadeh *et al*., 2010).

## CONCLUSIONS

Evaluation of detaching force and detaching time can help in the designing aspects i.e. reducing the material requirement for thresher fabrication and for

developing the cylinder and grate spacing. As it was observed that the power requirement for cumin threshing is very less, excess investment may be avoided by the adoption of lower wattage power source.

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