

Original Research Article

<https://doi.org/10.20546/ijcmas.2021.1002.040>

Effect of Grain Moisture Content on Rupture Force of Paddy

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ABSTRACT

Keywords

Rupture force, Grain moisture content, Loading rate, Paddy

Article Info

Accepted:
12 January 2021
Available Online:
10 February 2021

Determination of rupture force is essential before designing any threshing equipment. A study was conducted at College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, India during Rabi 2020 to find rupture force of paddy grain. The grain rupture force of six varieties of paddy were determined at four levels of grain moisture content and three levels of loading rate by using Universal Testing Machine. The rupture force of each variety was determined at three loading rate of 10, 15 and 20 mm per min at same four levels of moisture content. It was observed that the rupture force decreased with increase in moisture content of paddy grain.

Introduction

Paddy (*Oryza sativa* L.) is an ancient cereal crop. In Odisha, about 70% of the population depend on agriculture. Out of the total cultivable land of 61.80 lakh hectare, paddy covers 38.80 and 3.00 lakh hectare in Kharif and Rabi season respectively (Anonymous, 2014-15). Threshing is an agricultural operations which is required to detach the grains from the bundle of panicles of any cereal crop particularly paddy and wheat. For developing a thresher, it is important to design the appropriate size of the threshing

cylinder. For this purpose, the rupture force of grain is one of the important parameters that need to be considered. Hence, the recent study was undertaken to determine rupture strength of paddy by using Universal Testing machine (UTM).

Many researchers have studied rupture force of agricultural products. Ribeiro *et al.*, (2019) assessed the mechanical properties of saccharine sorghum seeds at different moisture contents. Compressive tests were performed through uni-axial tests for a sample of 15 seeds at different moisture content.

Their results indicated that the compressive force required to deform saccharine sorghum seeds decreased with increasing moisture content. They also mentioned that the reduction in moisture content caused an increase in the force required to rupture the seeds. Tavakoli *et al.*, (2009) studied the effect of moisture content and loading rate on fracture resistance of barley grains. The barley grains were quasi-statically loaded with two levels of loading rates 5 and 10 mm/min and four levels of moisture content 7.34, 12.11, 16.82, and 21.58% dry basis. It was observed that the force required for initiating the grain rupture decreased from 161.97 to 93.94 N with the increase in the moisture content from 7.34 to 21.58% dry basis. Saiedirad *et al.*, (2008) studied the effects of seed size, seed orientation, loading rate and moisture content on the force and energy required for fracturing cumin seed under quasi-static loading. Their results showed that seed rupture force decreased from 15.7 to 11.96 N with an increase in the moisture content from 5.7 to 15% dry basis. Konak *et al.*, (2002) evaluated several physical properties of chick pea seeds as function of moisture content. He revealed that the rupture force decreased with the increase in the moisture content of the chick pea seeds. The highest rupture force of chick pea seed was reported as 210 N with a moisture content of 5.2% dry basis. Waananen and Okos (1988) studied failure properties of yellow-dent corn kernels under uni-axial compressive loading at four levels of temperature and moisture content. He revealed that the failure stress of corn decreased and failure strain increased when moisture content and temperature increased. Prasad and Gupta (1973) studied the behaviour of paddy grain under quasi-static compressive loading. He opined that the maximum compressive strength of paddy grain decreased with increase in moisture content. This study aimed to investigate the

effect of moisture content and loading rate on the grain rupture force of different varieties of paddy prevailing in the state of Odisha by using Universal Testing Machine (make: Tinius Olsen, model: 5 kT, capacity: 5 kN).

Materials and Methods

This study was carried out in College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, India. Local popular rice varieties namely Lalat and Pratibha (long grain), Birupa and Pratikshya (medium grain), Sidhanta and Hasanta (short grain) were taken for the study to find the rupture force of grain at various grain moisture contents. At the end of crop maturity, each paddy variety was harvested and collected from field. The panicles were randomly selected from the harvested paddy bundles and sealed in a plastic packet and tested on the same day in the laboratory.. The individual grain of each variety was loaded between the two cross head and the compression plate. The grain was kept on the lower compression plate and the cross head moves towards the lower fixture plate. When the grain gets compressed and cracked, the rupture force was recorded (Fig.1). After the experiment, the moisture content of paddy grain was measured by using grain moisture meter. Similarly, rupture force of all collected samples were determined. After sun drying of each variety for 4 hours, the experimental procedure was repeated. and three levels of loading rate (50, 100, 150 mm/min) and for determining the rupture force, the experiment was carried out at same four levels of moisture content (17.5 ± 0.5 , 16.5 ± 0.5 , 14.5 ± 0.5 and 13.5 ± 0.5 %) and three levels of loading rate (10, 15, 20 mm/min).

Results and Discussion

The rupture force of different varieties of paddy at four levels of grain moisture content and three levels of loading rate was measured.

Rupture force of paddy grain

The rupture force of grains of six paddy varieties namely Lalat, Pratibha, Birupa, Pratikshya, Sidhanta and Hasanta at four levels of moisture content were measured at three levels of loading rate (10, 15, 20 mm/min) and the results are presented in Table 1.

Effect of moisture content on rupture force

For paddy variety Lalat (long grain), the rupture force increased from 116.8 to 156.7N

at 10mm/min, 101.6 to 144.1N at 15mm/min and 88.2 to 121.8N at 20mm/min as the moisture content decreased from 17.6 to 13.2%. For paddy variety Birupa (medium grain), the rupture force increased from 18.6 to 167.5N at 10mm/min, 99.3 to 156.2N at 15mm/min and 86.2 to 141.4N at 20mm/min as the moisture content decreased from 17.6 to 13.8%. Similarly for paddy variety Hasanta (short grain), the rupture force increased from 109.4 to 151.6, 97.9 to 140.5 and 85.4 to 129.8N as the moisture content decreased from 17.7 to 13.3% at same loading rate variation of 10 to 20 mm/min respectively.

Table.1 Rupture force (N) of paddy grain at various loading rate

Variety	Moisture content, %	Loading rate, mm/min		
		Rupture force, N		
		10	15	20
Lalat	17.6	116.8	101.6	88.2
	16.4	128.9	112.9	97.6
	14.4	142.6	135.7	106.4
	13.2	156.7	144.1	121.8
Pratibha	17.4	123.2	115.4	101.9
	16.1	142.9	133.6	120.7
	14.2	169.5	145.8	137.0
	13.0	188.1	169.5	150.3
Birupa	17.6	108.6	99.3	86.2
	16.3	127.9	115.1	102.8
	14.7	148.2	133.7	126.3
	13.8	167.5	156.2	141.4
Pratikshya	17.2	132.4	121.9	107.8
	16.2	145.2	132.6	124.0
	14.3	183.3	168.2	151.1
	13.4	196.9	179.7	168.6
Sidhanta	17.8	134.0	120.1	109.3
	16.7	147.9	132.4	121.8
	14.9	157.3	145.6	133.9
	13.6	178.6	167.7	156.8
Hasanta	17.7	109.4	97.9	85.4
	16.6	121.3	111.4	101.9
	14.5	144.9	132.5	126.3
	13.3	151.6	140.5	129.8

Table.2 Analysis of variance of rupture force of single grain

Source of variation	Degree of freedom	Sum of squares	Means of squares	F _{cal}	C.D	
					1%	5%
Variety	5	29453.254	5890.651	7201.2074	0.393388	0.29787
Grain moisture content	3	80163.028	26721.009	32665.9207	0.321341	0.243316
Variety x moisture content	15	3522.977	234.865	287.1181	0.787036	0.595937
Loading rate	2	24702.076	12351.038	15098.9067	0.278269	0.210703
Variety x loading rate	10	634.948	63.495	77.6212	0.681576	0.516084
Grain moisture content x loading rate	6	173.069	28.845	35.2622	0.556538	0.421406
Variety x grain moisture content x loading rate	30	835.074	27.836	34.0287	1.363152	1.032167
Error	144	117.793	0.818			
Total	215	139602				

Coefficient of variation: 0.68%

Fig.1 Measurement of rupture force of grain by Universal Testing Machine

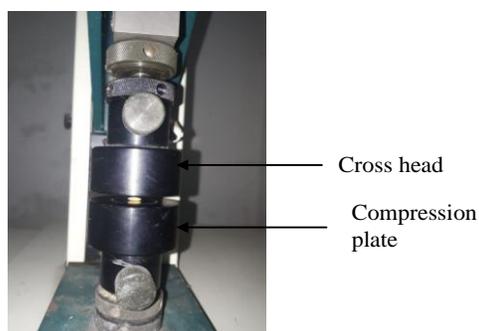


Fig.2 Rupture force of grain of different varieties at various moisture content

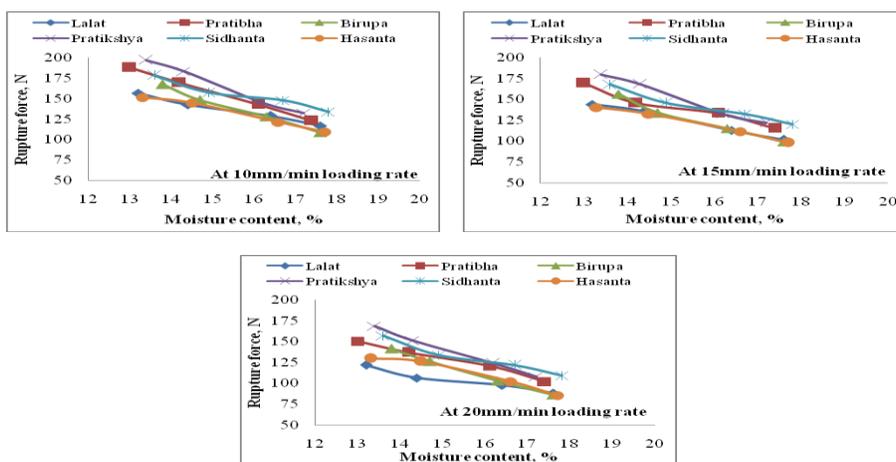
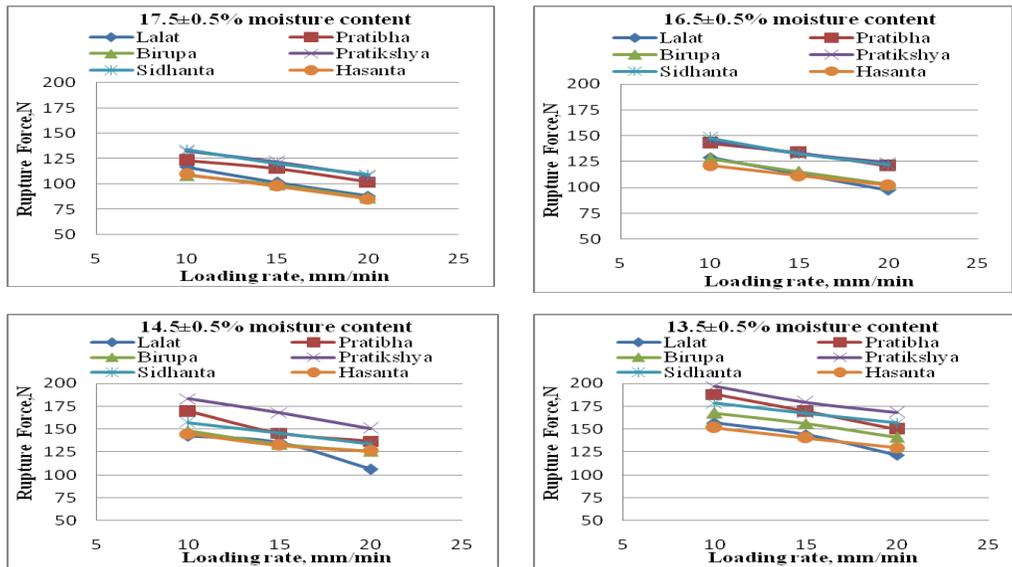


Fig.3 Rupture force of single grain of different varieties at various loading rate



Similar trends were observed for all varieties of paddy grains at four levels of moisture content at three levels of loading rate (Fig.2). It was observed that the rupture force increased with decrease in grain moisture content. This may be due to the fact that at higher moisture content, the grain became softer and required less force while at lower moisture content, grain became harder and required higher force to rupture. Such behaviour can be related to higher cellular density that occurred with reduction of moisture content from the grain i.e. as number of cells per unit volume increased; it resulted in a greater resistance to compression at lower moisture contents. This conclusion is in agreement with the findings of Ribeiro *et al.*, (2019) and Kotak *et al.*, (2002).

Effect of loading rate on rupture force

The effect of loading rate on the rupture force of single grain was determined at three levels of loading rate of 10, 15 and 20 mm/min. For paddy variety Lalat (long grain), the rupture force decreased from 116.8 to 88.2, 128.9 to 97.6, 142.6 to 106.4 and 156.7 to 121.8N as

loading rate increased from 10 to 20 mm/min at 17.6, 16.4, 14.4, 13.2% moisture content respectively. For paddy variety Birupa (medium grain), the rupture force decreased from 108.6 to 86.2, 127.9 to 102.8, 148.2 to 126.3 and 167.5 to 141.4N as loading rate increased from 10 to 20 mm/min at 17.6, 16.3, 14.7 and 13.8% moisture content. Similarly for paddy variety Sidhanta (short grain), the rupture force decreased from 134.0 to 109.3, 147.9 to 121.8, 157.3 to 133.9 and 178.6 to 156.8N when loading rate varied from 10 to 20 mm/min at 17.8, 16.7, 14.9 and 13.6% moisture content respectively. Similar trends were also observed for all varieties of paddy grain at various moisture contents when loading rate increased (Fig.3). It was observed that the rupture force decreased with increase in loading rate at all four levels of moisture contents. This finding is consistent with the result presented by Tavakoli *et al.*, (2009).

The analysis of variance (ANOVA) of grain rupture force of different varieties is presented in Table 2.

From table 2, it was seen that the variety, grain moisture content and loading rates have significant effect on rupture strength of grain. The interaction between variety and moisture content, variety and loading rate, moisture content and loading rate have significant effect on rupture strength. Also, the combined effect of variety, moisture content and loading rates has significant effect on rupture strength of grain.

In conclusion the rupture force of single grain of six popular varieties of paddy in the state were determined at four levels of grain moisture content varying from 13.0 to 17.8% by using UTM. The grain rupture force for each variety was undertaken at three levels of loading rate of 10, 15 and 20 mm/min at same four levels of moisture content. The following conclusions were drawn from this study.

The rupture force decreased as the grain moisture content and loading rate increased.

The maximum rupture force (196.9 N) obtained for Pratikshya variety at lowest moisture content of 13.4% at lowest loading rate of 10mm/min while the minimum force (85.4N) required for Hasanta variety at higher loading rate of 20 mm/min at highest moisture content of 17.7%.

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How to cite this article:

Prerana P. Jena, A. K. Goel, S. K. Swain, R. R. Pattnaik and Behera, D. 2021. Effect of Grain Moisture Content on Rupture Force of Paddy. *Int.J.Curr.Microbiol.App.Sci*. 10(02): 346-351. doi: <https://doi.org/10.20546/ijcmas.2021.1002.040>