Effect of husking and whitening machines on rice Daillman cultivar

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Abstract: The effect of husking and whitening machines on rice, Daillman Mazandarani (DM) cultivar was studied based on some technical indicators. Two types of machines (Satake and Yanmar) were tested at three clearances of 0.4, 0.6 and 0.8 mm between cylinders and three ranges of grain moistures of 10%-12%, 12%-14% and 14%-16%. The experiments were carried out in a factorial experiment under complete randomized design with three replications. The results showed that the Satake machine was significantly better than the Yanmar machine in all studied conditions. The results showed a production process of 1.525 and 1.300 t\h, power consumption of 14.972 and 15.601 kW, milling recovery of 69.257% and 68.369%, broken rice of 7.343% and 8.232%, husking efficiency of 83.212% and 81.703% and head rice yield of 68.750% and 66.905% for Satake and Yanmar machines, respectively. The clearance 0.8 was significantly superior to the other two levels of 0.4 and 0.6 mm while the moisture content of grain at range of 10%-12% was significantly superior to the other ranges of 12%-14% and14%-16% in all studied conditions.

Keywords: rice, Daillman Mazandarani cultivar, husking, whitening, moisture content

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1 Introduction

A vast majority of people in the world consume rice. It is the second most important cereal in the world and provides, together with wheat, a large proportion (95%) of the total nourishment of the world’s population. It is the daily food for over 1.5 billion people as it is so popular and easily digested. Rice is an essential food in the diet of one third of the world’s population and further stated rice production and consumption is concentrated in Asia where more than 90% of the world’s rice is produced and consumed. The 155 million hectares planted throughout the world and produce about 596.5 million metric tons of paddy rice per year. Rice, which is grown under a wide diversity of climates, soils and production systems, is subjected to many biotic and abiotic stresses that vary according to the site. Consumption per capita and consumer preferences for a given rice type also vary from region to region. Rice is now a major staple food for millions of people in Asia.

The removal of bran as the milling duration and grain moisture content increased in linear reduction of head kernel yield (Bautita et al., 2002). A high milling degree means that the milled rice is very white with relatively light milling. Degree of milling is influenced by the grain hardness, size, shape, depth of surface ridges, bran thickness and mill efficiency. It also affects milling recovery and influences consumer acceptance (Richman et al., 2006). The compressive load resistance of rice grain is based on its characteristic of yield strength of which can be expressed as relationships of the shear strength. Two similar experiments, both parallel and cross grain positions were conducted on the rough rice and brown rice to determine the power consumption of the machines as well

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as lowering the broken rice during the rice mill processes (Chaitep et al., 2008). The broken grain size which is less than a quarter of the length of the pill and back are due to several factors, including the organization of the machine and grain moisture content during the manufacturing stage in addition to the mechanical stresses experienced by the grain harvest in the pre-manufacturing stage (Al Sharifi, 2010).

Milling is the final step in rice post-harvest processing, which includes pre-cleaning, husking, whitening and grading in the rice milling process (Ohtsubo et al., 2005). Paddy is first thoroughly cleaned by a paddy cleaner and then the husk is removed by any of the existing husker. Rubber roll husker is the most popular machine for husking of paddy in the milling operation because of its better performance in quality and quantity in comparison to other kind of huskers. The performance of a husker is not only governed by the working parameters of the machine, but also the physical and morphological characteristics varietal properties of the paddy. The effect of clearance between the cylinders has a significant effect on the breakage of rice (Williams et al., 2002). The more clearance between the cylinders leads to the percentage of breakage, so it is concluded that the excess clearance proportion gives less breakage unlike little clearance is due to an increase in the mechanical effort, which involved a rice grain during the milling.

The moisture content is a major factor affecting the milling quality of rice. If the moisture content is too low or too high, there will be a decline in the milling recovery and head rice (Patindol, 2000). The highest broken rice was resulted with moisture level of 14%. It has also been concluded that the abrasive milling system caused less broken compared to milling systems include rubber roll huller and blade whitener as well as system with blade husker and blade whitener (Mead et al., 2003).

Cereal grains, mainly paddy, wheat, millets and maize are consumed globally in one form or the other (Puri et al., 2014). Paddy is a staple food grain of India and is composed of husk, bran and endosperm. It is milled to a certain degree before consumption. After milling, the amount of bran left on milled paddy kernels is measured and is termed as the degree of milling. Milling recovery is the percentage of milled paddy (total paddy yield) obtained from the sample of the paddy after milling. It can be computed by dividing the weight of the milled or polished paddy recovered by the weight of the paddy sample used (Gbabo and Ndagi, 2014). The effect of different types of crunches and whitening machines on the paddy grains were tested on two varieties of Amber 33 and Abasiya. The results showed that there is a significant effect to the machine type as well as the type of paddy on milling recovery (Al Maamouri and Al Sharifi, 2008). Chalkiness an opaque white discoloration of the endosperm reduces the value of head rice kernels and decreases the ratio of head to broken rice produced during the milling process (Lobell et al., 2012). The comparison of milling efficiency factors between experimental results and simulation results showed that the differences in hulling efficiency, milling efficiency, milled rice recovery between experiment and simulation were 0_10%, 0_7%, 0_4%, respectively. Although the simulation results were a little lower than experimental ones, they are close (Chung and Lee, 2003). The materials produced in the processes of simulation were compared with those in the experiments.

The main goal of this research is to study the effect of husking and whitening machines (Satake and Yanmar) on rice, Daillman Mazandarani (DM) cultivar at different clearances between cylinders and different ranges of grain moisture content.

2 Materials and methods

This study was conducted in 2015 to evaluate the effect of husking and whitening machines (Satake and Yanmar). The experiments were done at three levels of grain moisture contents of 10%-12%, 12%-14% and 14%-16% and three clearances between cylinders at levels of 0.4, 0.6 and 0.8 mm. The Daillman Mazandarani (DM) cultivar was selected for the experiments and the samples were taken by the probe and collected on the form of heap, which the number heaps were six and each heap weight was 160 kg, according to the method used by Alshrifi (2010). The paddy samples were cleaned by using sieves to remove all foreign matters, broken and immature grains. Then the random samples which are taken from each heap in 1000 g weight. The initial moisture content of paddy grain was determined by oven drying methods at 103 ℃ for 48 h (Sacilik et al., 2003). The paddy of DM cultivar was kept in an oven at temperature of 43 ℃ and monitored carefully for determining the moisture content of grain at 14%-16% then the samples were taken and placed in the precision divider to get a sample of 200 g weight and then the samples were carefully sealed in polyethylene bags. The Satake type machine was adjusted on 0.8 mm clearance between cylinders and linear speed of 4.7 m/s and then the samples of 200 g were placed in the machine. Then the sample was taken out of the machine and placed in a cylindrical insulating device from a Satake type with operating time which was adjusted to 2 min. The angle of inclination was 25° insolating the broken and full grain for all sizes. The production process, power consumption, milling recovery, the breakage proportion, percentage of head rice and husking efficiency were calculated for each running test.

2.1 Production process

The production process of the machine was determined by the efficiency of the machine, which depends on the type of the machine as well as the size and moisture content of the grain and also the machine capacity. This is the quantity of the paddy that passes through the machine per unit time (Equation 1) (Roy and Rob, 2007)

$$P = \frac{W \times 60}{T \times 1000} P = \frac{W \times 60}{T \times 1000}$$

Where, *P* is production process (t/ht/h), *W* is output weight (g), and *T* is time (min).

2.2 Power consumption

Power consumption is the power, which is consumed by a machine to perform a specific job. The power consumption for this research was calculated by using Equation 2 (Al Saadi and Al Ayoubi, 2012).

$$P = \frac{\sqrt{3}}{1000} \cdot v \cdot I \cdot \cos\varphi \cdot E_{FE}$$

Where, *P* is power consumed (kW), *V* is voltage (V) and *I* is the electric current (A), $cos\,\varphi$ is the angle between the current and voltage, and E_{FE} is the efficiency of the motor (%).

2.3 Milling recovery

The milling recovery is the quantity of milled paddy obtained from a certain quantity of paddy. It is expressed as a percentage of milled paddy including broken obtained from paddy, which can be calculated by Equation 3 (Al saadi and Al Ayoubi, 2012).

$$M_{r=\frac{W_M}{W_s}\times 100}$$

Where, M_r is the milling process (%), W_M is the weight of milling paddy (g), and W_s is the weight of the sample used (g).

2.4 Breakage proportion

The Equation 4 was used to calculate the percentage of the head paddy and broken in the separation process of the broken grain from the head grains (Gbabo and Ndagi, 2014).

$$P_{Br=\frac{W_{br}}{W_s}\times 100}$$

Where, P_{Br} is the proportion of breakage paddy (%), W_{br} is the weight of breakage grain (g) and W_s is the weight of paddy sample used (g).

2.5 Percentage of head rice

Percentage of head rice represents the amount of head grains resulting from the husking process and broken grains and cracked grain percentage (Equation 5) (Ali and Shatti, 2006).

$$P_{Fg} = \frac{W_{Fg}}{W_S} \times 100$$

Where P_{Fg} is the proportion of head grain (%), W_{Fg} is the weight of head grain (g) and W_S is the weight of paddy sample used (g).

2.6 Husking efficiency

The husking efficiency was determined by using Equation 6 (Minaei et al., 2007).

$$P_E = \frac{W_S - W_{RU}}{W_S} \times 100$$

Where P_E is the husking efficiency (%), W_{RU} is the weight of unhusked paddy (g) and W_S is the weight of paddy sample used (g).

The same method was used with the same cultivar (DM) to test the Satake type (Figure 1) and Yanmar type (Figure 2) machines at grain moisture content of 12%-14% and 14%-16% and clearances of 0.4 and 0.6 mm in three replications. The results were analyzed statistically using the design complete randomized design (CRD) and the difference among treatments for each factor was tested according to the LSD test (Alsahoeke and Creama, 1990).

Figure 1 Machine (type Satake) used for hulling paddy

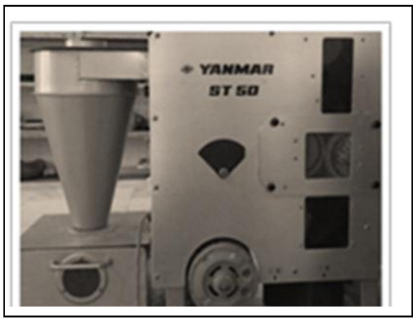

Figure 2 Machine (type Yanmar) used for hulling paddy

3 Results and discussion

3.1 Production process

The influence of machine type, clearance between cylinders and grain moisture content on rice production process t/h is shown in Table 1. The clearance at 0.8 mm showed the highest production process of 1.682 t/h, while the lowest production process of 1.190 t/h was for 0.4 mm clearance. These results are consistent with the results that gained by previous researchers (Corrêa et al., 2007). It is indicated that the production process of the Satake machine (1.525 t/h) is significantly better than Yanmar machine (1.300 t/h). This is due to the use of full absorption capacity of the Satake machine. These results are consistent with the results of (Sigh et al., 2005). As increasing the grain moisture content leads to decrease of the paddy productivity, the results were 1.663, 1.384 and 1.222 t/h for different levels of moisture content, when increasing grain moisture, leads to an obstruction process husk of grain and this because of the adhesion of grain. These results are consistent with the results of (Patindol, 2000). All the interactions are significantly different and the best results (1.998 t/h) have come from the overlap among Satake machine, 10%-12% grain moisture content and 0.8 mm clearance. The levels of the production process at different conditions are shown in Figure 3 for both machine types (Satake and Yanmar).

Table 1 Effect of machine types, clearances and grain moistures on the production process, t/h

Machines	Grain moisture,%	Clearance between cylinder/mm			Average production process, t/h
		0.4	0.6	0.8	
Yanmar	10-12	1.150	1.433	1.963	1.515
	12-14	1.006	1.181	1.554	1.247
	14-16	1.001	1.101	1.316	1.139
Satake	10-12	1.564	1.691	1.998	1.751
	12-14	1.346	1.516	1.701	1.521
	14-16	1.074	1.276	1.560	1.303
L.S.D=0.05			0.086		0.024
Average of clearance/mm		1.190	1.619	1.682	
L.S.D=0.05			0.035		
Machines	The average production process of each machine and clearance				Average of each machine
Yanmar	1.052		1.238	1.611	1.300
Satake	1.328		1.494	1.753	1.525
L.S.D=0.05				0.049	0.028
Grain moisture/%	The average of each grain moisture and clearance				Average of each grain moisture
10-12	1.357		1.562	1.981	1.633
12-14	1.176		1.349	1.628	1.384
14-16	1.038		1.189	1.438	1.222
L.S.D=0.05				0.060	0.035

Note: L.S.D means Least Significant Difference

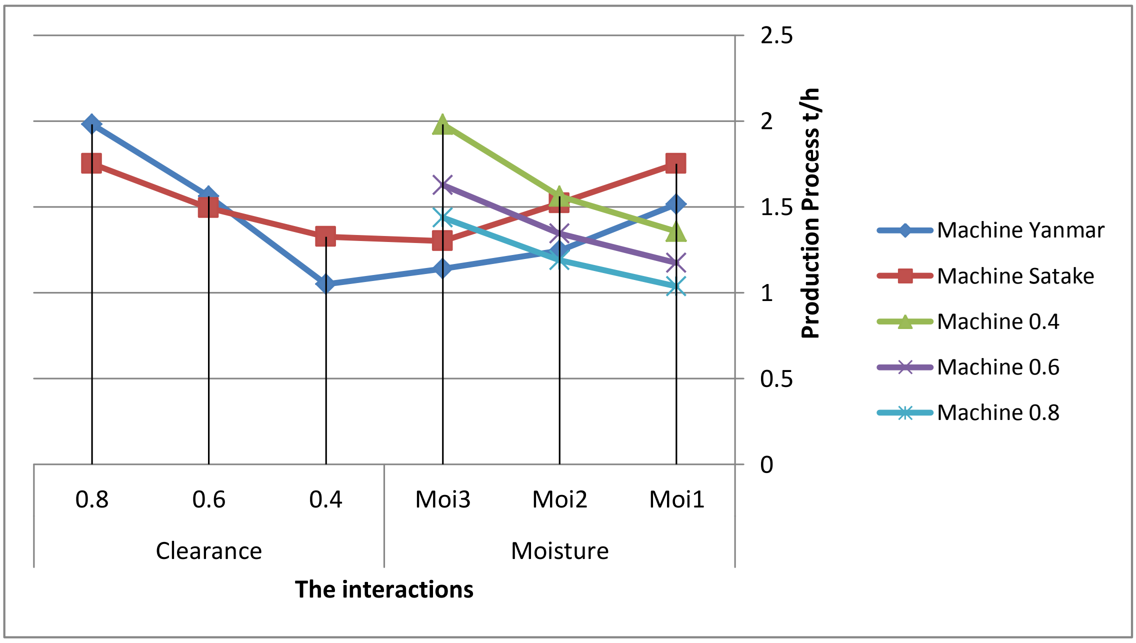

Figure 3 Effect of clearance and grain moisture on the production process for two machines

3.2 Power consumption

Table 2 shows the influence of machine type, clearance and grain moisture on power consumption (kW). The results indicated that increasing the clearance between cylinders leads to decrease the power consumption of the machine, and the results were 16.164, 15.372 and 14.324 kW for different clearances. This is due to the efficiency of the machine in the work achieved and less time. The capacity consumed was less when the clearance among cylinders increased, hence power consumption increased. These results are consistent with the results that gained by (Chaitep et al., 2008). As increasing the grain moisture leads to increase of the power consumption and the results were 14.675, 15.308 and 15.877 kW at different moisture contents. This is due to the increased Damocles effort on grains during the hulling process, hence increased capacity consumed with increasing moisture content of grain. These results are consistent with the results of (Al Saadi and Al Ayoubi, 2012). However, Satake machine was significantly better than the Yanmar machine, while the results gained from this process were 15.601 and 14.972 kW for Satake and Yanmar machines respectively. Because of high quality in hulling process, less capacity was consumed when Satake machine was used to compare with Yanmar machine. These results are consistent with the results of (Al Maamouri and Al Sharifi, 2008). All the interactions were significant and the best results 13.104 kW was achieved for Satake machine, at 10%-12% grain moisture content and 0.8 mm clearance. The level of the power consumption at different conditions is shown in Figure 4 for both machine types (Satake and Yanmar).

Table 2 Effect of machine types, clearances and grain moistures on the power consumption, kW

Machines	Grain moisture,%	Clearance between cylinder/mm			Average moisture,%
		0.4	0.6	0.8	
Yanmar	10-12	15.882	15.037	14.078	14.999
	12-14	16.420	15.395	14.780	15.532
	14-16	17.095	16.109	15.618	16.274
Satake	10-12	15.089	14.857	13.104	14.350
	12-14	16.020	15.190	14.043	15.084
	14-16	16.480	15.642	14.321	15.481
L.S.D=0.05				0.160	0.092
Average clearance		16.164	15.372	14.324	
L.S.D=0.05				0.065	
Machines	The average of moisture of each clearance for the machines				Average moisture of each machine
Yanmar	16.465	15.514	14.825		15.601
Satake	15.863	15.230	13.823		14.972
L.S.D=0.05			0.092		0.053
Grain moisture/%	The average grain moisture at each clearance				Average grain moisture
10-12	15.486	14.947	13.591		14.675
12-14	16.220	15.293	14.412		15.308
14-16	16.787	15.875	14.969		15.877
L.S.D=0.05			0.113		0.065

Note: L.S.D means Least Significant Difference

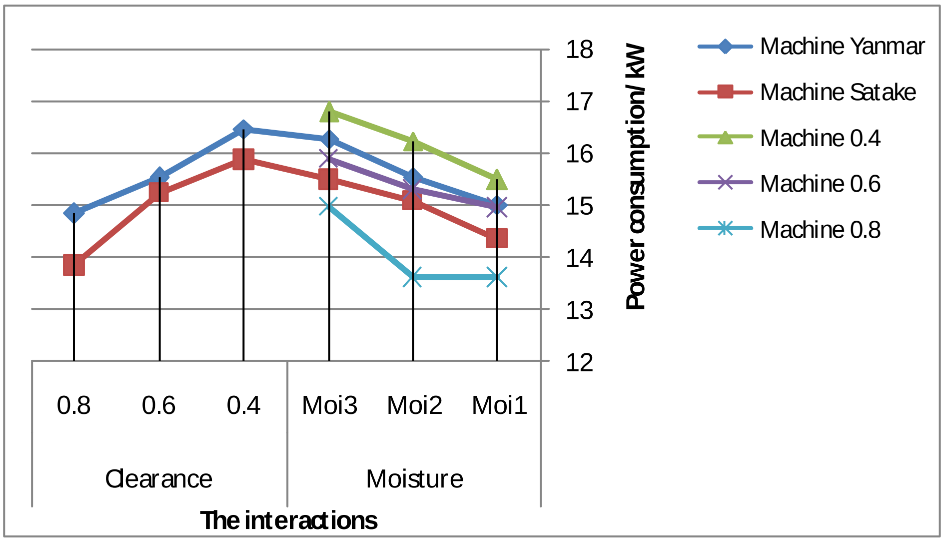

Figure 4 Effect of clearance and grain moisture on the power consumption for two machines

3.3 Milling recovery

Table 3 indicates that increasing the grain moisture leads to decreasing percentage of milling recovery. The milling recovery levels were 69.736%, 68.793% and 67.910% at different moisture contents. Higher grain moisture content leads to difficulty in separation of the crust from the grains hence decrease in percentage of milling recovery. These results are consistent with the results of (NurulAfsar et al., 2001). The Satake machine (68.369%) was significantly better than the Yanmar machine (69.257%). This is due to the characteristics design of engineering, which characterized by Satake machine compared with Yanmar machine. These results are consistent with the results of (Gbabo and Ndagi, 2014). In addition, increasing the clearance between cylinders leads to increase the percentage of milling recovery of the machine. The results were 67.888%, 68.784% and 69.768% at different clearances. This is due to increased mechanical energy for separation process of the husking of grain. The increase in clearance among cylinders, leads to increase in percentage of milling recovery. These results are consistent with the results that gained by (Corrêa et al., 2007). The best result (71.028%) was obtained by Satake machine at grain moisture content of 10%-12% and 0.8 mm clearance. The milling recovery levels at different conditions are shown in Figure 5 for both machines.

Table 3 Effect of machine types, clearances and grain moistures on the milling recovery, %.

Machines	Grain moisture,%	Clearance between cylinder/mm			The average of milling recovery, %
		0.4	0.6	0.8	
Yanmar	10-12	68.114	69.418	70.058	69.197
	12-14	67.094	68.198	69.684	68.325
	14-16	66.819	67.360	68.577	67.585
Satake	10-12	69.253	70.547	71.028	70.276
	12-14	68.781	69.006	69.993	69.260
	14-16	67.265	68.173	69.268	68.235
L.S.D=0.05				0.147	0.085
Average of clearance		67.888	68.784	69.768	
L.S.D=0.05				0.060	
Machines	The average of each machine and clearance/%				Average of machine
Yanmar	67.342	68.326		69.439	68.369
Satake	68.433	69.242		70.096	69.257
L.S.D=0.05				0.085	0.049
Grain moisture/%	The average of each grain moisture and clearance				Average of grain moisture
10-12	68.683	69.983		70.543	69.736
12-14	67.938	68.602		69.839	68.793
14-16	67.042	67.767		68.922	67.910
L.S.D=0.05				0.104	0.060

Note: L.S.D means Least Significant Difference

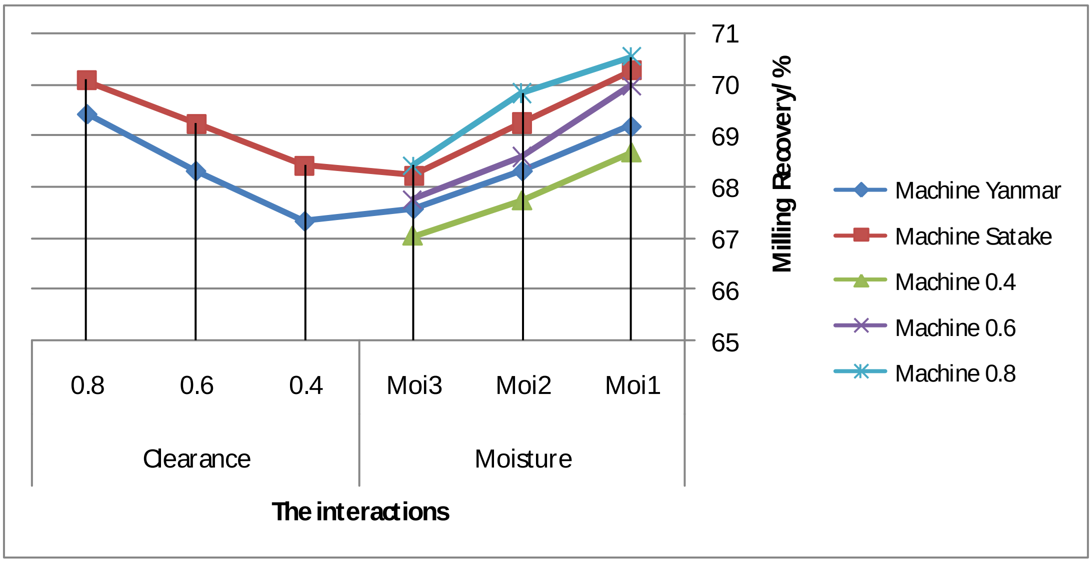

Figure 5 Effect of clearance and grain moisture on the milling recovery for two machines

3.4 Breakage grain

Table 4 shows the percentage of the broken rice of both machine types at different levels of grain moisture and clearances between cylinders. The results showed that the breakage percentage was a significant effect at different moisture contents. Increasing the moisture content caused an increase in breakage percentage which was 7.049%. The highest breakage percentage accompanied 8.604%. This is due to the low Damocles effort on grains when the Satake machine is used to compare with the Yanmar machine because the ease grain flow, leads to increase the proportion of breakage grain with increase in moisture content. This is consistent with the results of (Al Maamouri and Al Sharifi, 2008). Increasing the clearance between cylinders leads to decrease the breakage percentage of the machine. The percentage of the broken grain were 8.789%, 7.773% and 6.801% at different clearances because of the less collisions of the grain with each other, which facilitates high flow of grain inside husking chamber when the clearance between the cylinders increased. The Satake type machine with less broken grains (7.343%) showed a significantly better performance than the Yanmar type machine (8.232%). The reasons are efficiency and type of machine and their ability to perform the requested operation. These results are consistent with the results of (Sigh et al., 2005). The best result (5.560%) was obtained by Satake type machine at 10%-12% grain moisture and 0.8 mm clearance. The levels of the broken rice percentage at different conditions are shown in Figure 6 for both machines (Satake and Yanmar).

Table 4 Effect of machine types, clearances and grain moistures on the percentage of breakage grain, %

Machines	Grain moisture,%	Clearance between cylinder/mm			The average of breakage,%
		0.4	0.6	0.8	
Yanmar	10-12	8.604	7.791	6.272	7.556
	12-14	9.042	8.375	7.107	8.175
	14-16	9.968	8.871	8.055	8.964
Satake	10-12	7.928	6.139	5.560	6.543
	12-14	8.155	7.328	6.247	7.243
	14-16	9.038	8.132	7.562	8.244
L.S.D=0.05			0.196		0.113
Average of clearance		8.789	7.773	6.801	
L.S.D=0.05			0.080		
Machines	The average of each machine and clearance				Average of machines
Yanmar	9.204	8.345		7.145	8.232
Satake	8.374	7.200		6.456	7.343
L.S.D=0.05			0.113		0.065
Grain moisture/%	The average of each grain moisture and clearance				Average of grain moisture
10-12	8.266	6.965		5.916	7.049
12-14	8.599	7.851		6.677	7.709
14-16	9.503	8.502		7.808	8.604
L.S.D=0.05			0.138		0.080

Note: L.S.D means Least Significant Difference

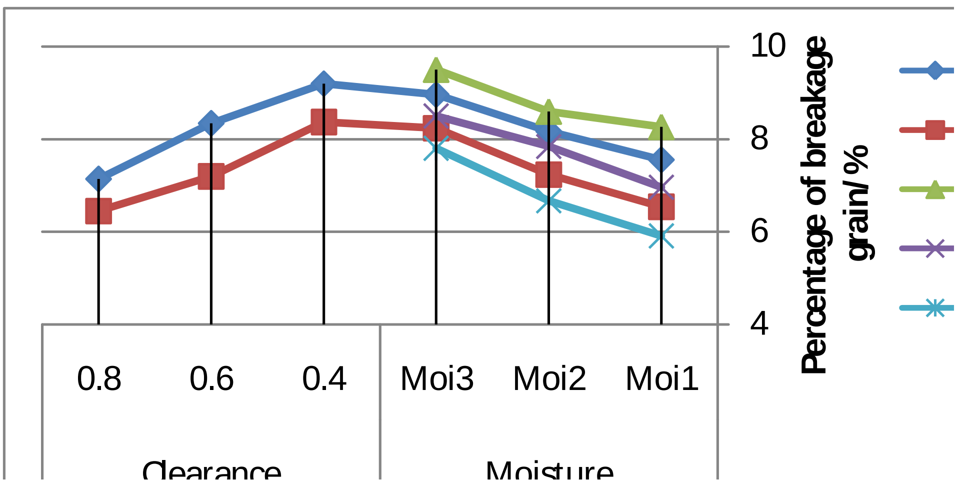

Figure 6 Effect of clearance and grain moisture on the percentage of breakage grain % for two machines

3.5 Head grain

Table 5 shows the influence of the machine type, clearance and grain moisture on the head rice percentage.

The results indicate that the Satake type machine with 68.75% is significantly better than the Yanmar type machine 66.91%. This is due to decrease the broken rice when Satake type machine is used to compare with a Yanmar type machine which gives the highest percentage of breakage hence decrease head rice percentage. These results are consistent with the results gained by (Bautita et al., 2002). Increasing the clearance between cylinders leads to increase the percentage of head rice. The percentage levels of head rice were 65.343%, 67.832% and 70.256% at different clearances because the percentage of breakage increased with the decrease in clearance between cylinders and negative effect on the ratio of head rice. These results are consistent with the results gained by (Patindol, 2000). Increase in grain moisture leads to decreasing the percentage of head rice. The values of head rice were 69.819%, 67.832% and 65.832% at different moisture contents because of the lack of withstanding of grains to pressure which facing the grains inside hulling chamber when the grain moisture content increased and leads to decrease in percentage of head rice. These results are consistent with the results of (Alsharifi, 2010). The best result (73.046%) was obtained by Satake type machine at grain moisture of 10%-12%, and clearance of 0.8 mm. The head rice percentage at different conditions is shown in Figure 7 for Satake and Yanmar machines.

Table 5 Effect of machine types, clearances and grain moistures on the percentage of head grain, %

Machines	Grain moisture,%	Clearance between cylinder/ mm			The average of head grain
		0.4	0.6	0.8	
Yanmar	10-12	65.769	68.635	71.719	68.707
	12-14	64.571	66.804	70.012	67.129
	14-16	62.909	64.670	67.056	64.878
Satake	10-12	68.204	71.541	73.046	70.930
	12-14	66.298	68.578	70.727	68.535
	14-16	64.308	67.070	68.977	66.785
L.S.D=0.05				0.298	0.172
Average of clearance		65.343	67.832	70.256	
L.S.D=0.05				0.121	
Machines	The average of each machine and clearance				Average of machine
Yanmar	64.416		66.703	69.596	66.905
Satake	66.270		69.063	70.917	68.750
L.S.D=0.05				0.172	0.049
Grain moisture/%	The average of each grain moisture and clearance				Average of grain moisture
10-12	66.987		70.088	72.383	69.819
12-14	65.435		67.691	70.370	67.832
14-16	63.609		65.870	68.017	65.832
L.S.D=0.05				0.210	0.121

Note: L.S.D means Least Significant Difference

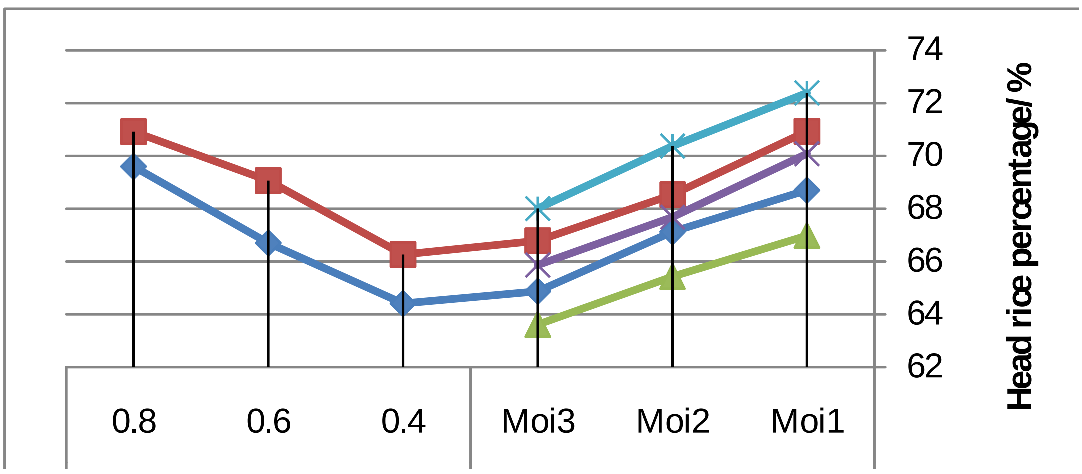

Figure 7 Effect of clearance and grain moisture on the percentage of head grain for two machines

3.6 Husking efficiency

Table 6 indicates to the influence of machine type, clearance and grain moisture on the husking efficiency. The results showed that increase in clearance between cylinders leads to increase husking efficiency of the machine. The results were 83.750%, 82.446% and 81.177% at different clearances. This is due to the increase in the production process by increasing the clearance between cylinders. These results are consistent with the results gained by (Williams et al., 2002). It indicates the Satake machine with higher husking efficiency (83.212) was significantly better than the Yanmar machine (81.703%). This is due to the full energy assimilation by Satake machine as compared with Yanmar machine. These results are consistent with the results of (Richman et al., 2006). As the increase of grain moisture leads to decrease of husking efficiency, the results were 84.084%, 82.364% and 80.925% at different moisture contents. The increase in moisture content of grain also leads to obstruct the husking process hence decreasing husking efficiency. These results are consistent with the results of (Minaei et al., 2007). The best result (86.107%) achieved by Satake machine at grain moisture of 10%-12% and 0.8 mm clearance. The levels of the husking efficiency at different conditions are shown in Figure 8 for both machine types (Satake and Yanmar).

Table 6 Effect of machine types, clearances and grain moistures on the husking efficiency

Machines	Grain moisture,%	Clearance between cylinder			The average of husking efficiency,%
		0.4	0.6	0.8	
Yanmar	10-12	84.878	82.932	81.775	83.195
	12-14	82.944	81.685	80.891	81.840
	14-16	81.192	80.224	78.811	80.075
Satake	10-12	86.107	84.943	83.867	84.973
	12-14	84.219	82.893	81.553	82.888
	14-16	83.159	82.000	80164	81.774
L.S.D=0.05				0.355	0.205
Average of clearance		83.750	82.446	81.177	
L.S.D=0.05				0.145	
Machines	The average of each machine and clearance				Average of machine
Yanmar	83.004	81.613		80.492	81.703
Satake	84.495	83.279		81.861	83.212
L.S.D=0.05				0.205	0.118
Grain moisture/%	The average of each grain moisture and clearance				Average of grain moisture
10-12	85.492	83.938		82.821	84.084
12-14	83.581	82.289		81.222	82.364
14-16	82.175	81.112		79.487	80.925
L.S.D=0.05				0.251	0.145

Note: L.S.D means Least Significant Difference

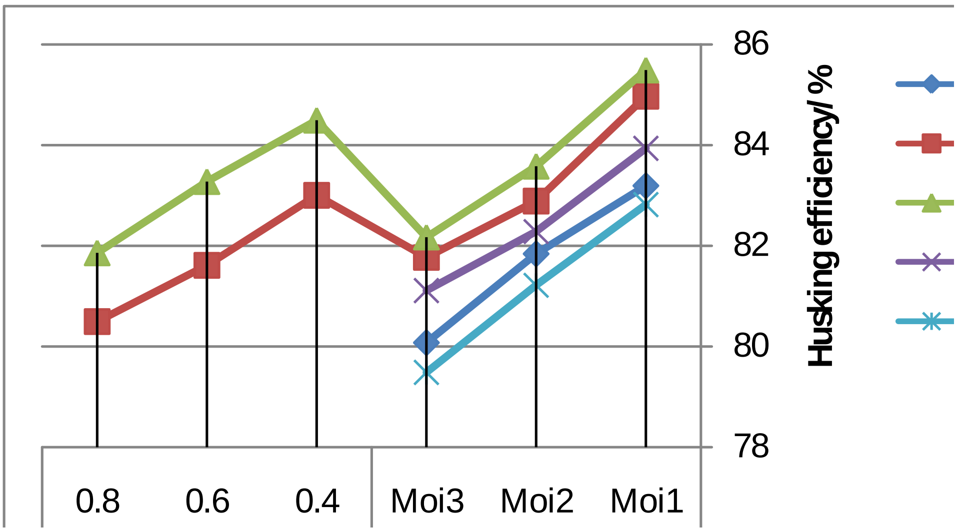

Figure 8 Effect of clearance and grain moisture on the husking efficiency for two machines

4 Conclusion

The Satake type machine is significantly better than the Yanmar type machine in all studied conditions. The grain moisture content of 10%-12% was significantly superior to the two levels 12%-14% and 14%-16%. The 0.8 mm clearance between the cylinders was significantly superior to the other two clearances of 0.4 and 0.6 mm. The results showed better conditions for the overlap between the Satake type machine and grain moisture content of 10%-12% and also for the overlap between the Satake type machine and 0.8 mm clearance compared to the overlap of the Yanmar type machine with other moisture grain contents and clearances. The best result was obtained by Satake type machine at grain moisture content of 10%-12% and 0.8 mm clearance.

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References

Ali, A. L., and R. Shatti. 2006. The impact of harvest dates in the manufacturing qualities in some varieties of paddy. *Journal Al Fatih*, 1(26):97-112

Al Maamouri, S. A., and S.K. Al Sharifi. 2008. Studies effect different types of machine crunches and whitening on the rice kernels varieties Anbbar 33 and Abasiya. *Journal of the University of Babylon*, 17(1):134-153.

Al Saadi, F. T., and T. Al Ayoubi. 2012. Study some of the technical characteristics of the type of excessive and the impact feed speed and drying temperature and their impact on the nutritional value of maize crop. *Euphrates Journal of Agriculture Science*, 2(3):70-76.

Alsahoeke, M. M. and M. Creama. 1990. Applications of design and analysis of experiment. Baghdad University, College of Agriculture, Ministry of Education and Scientific Research. Pp. 49-88.

Al Sharifi, S. K., and A. S. Mousa. 2009. Study of some qualitative characteristics to two varieties of rice, the effect of two types of machines bleach and crunches and weighted moisture content. *Journal of the University of Babylon*, 17(1):121-141.

Al Sharifi, S. K. A. 2010. Effect of different husking and whitening machines to rice kernel varieties Abasiya and Mushkhab 1 for both seasons 2006, 2007. *Euphrates Journal of Agriculture Science*, 2(3):11-35.

Chaitep, S., R. Chaiy, and W. Pipatpong. 2008. Compressive load resistance characteristics of rice grain. *American Journal of Agricultural and Biological*, 3(1):325-329

Chung, J. H., and Y. B. Lee. 2003. Simulation of a Rice Mill Process. *Biosystems Engineering*, 86(2):145-150. Available online at www.sciencedirect.com.

Corrêa, P. C., F. S. da Silva, C. Jaren, P. C. Afonso Júnior, and I. Arana. 2007. Physical and mechanical properties in rice processing. *Journal of Food Engineering*, 79(1):137-142.

Gbabo, A., and B. Ndagi. 2014. Performance evaluation of a rice mill developed in NCRI. *International Journal of Engineering Research*, 3(8):482-487.

Minaei, S., M. R. Alizadeh, M. H. Khoshtaghaza, and T. Tavakoli. 2007. Effects of de-awning and moisture content on husking characteristics of paddy in rubber-roll husker. *American-Eurasian Journal of Agric & Environ Sci.*, 2(1):01-05.

NurulAfsar, A. K. M., B. Mohammad, R. Mahfoozu, and M. Abdur Rouf. 2001. Grades standards and inspection procedures of rice in Bangladesh FMRSP working paper. No 28.

Ohtsubo, K., K. Suzuki, Y. Yasui, and T. Kasumi. 2005. Bio-functional components in the processed peregrinated brown rice by a twin-screw extruder. *Journal of Food Comp. Ana.* 18(4):303–316.

Patindol, J. A. 2000. Methods and Standards for Rice Grain Quality Assessment in the Philippines. Quality Assurance in Agricultural Produce. Pp. 302-307.

Puri, S., B. Dhillon, and S. N. Sodhi. 2014. Effect of degree of milling (DOM) on overall quality of rice - A review. *International Journal of Advanced Biotechnology and Research*, 5(3):474-489.

Roy, S. M., and A. Rob. 2007. Business Rationale for Investment on Power Operated Maize Sheller in Bangladesh. *Agricultural Engineering International: CIGR Journal*, Invited overview, 9(3):1-13

Sacilik, K., R. Ozturk, and R. Keskin. 2003. Some physical properties of hemp seed. *Journal of Biosystems Engineering*, 86(2):191–198.

Williams, J. F., J. F. Thomson, and R. G. Mutters. 2002. Rice milling quality. University of California Rice Research Quietly. Vol. 1 California.