The Effect of Aeration and Circulation Treatments on Maintaining Quality of Bulk Stored Paddy Rice

Doaa A. A. Abd el Bary and Ahmed R. Khatab[1]

ABSTRACT

Bulk storage is, progressively, becoming an important method for paddy rice storage in Egypt. This study was carried out to investigate the role of aeration in maintaining quality of raw paddy rice stored in bulk. Three aeration treatments, i.e., no aeration (control), aeration by using a centrifuge fan and circulation, were tested for a period of six months. Aeration treatments were applied every two weeks. Random samples were drawn from three sections in each bin i.e., upper, middle and lower, at each interval.

The results indicated that aeration treatments, sampling sections and sampling dates (storage duration) caused significant changes in the studied characteristics of stored paddy especially, temperature and moisture content of grains. Aeration treatments tended to decrease number of pests in stored rice, thus, maintaining the quality of stored rice throughout the storage period. Significant simple correlation coefficients were, also found between pairs of studied characters such as moisture and 1000 grain weight (0.31*), bran and germ percentage (0.224*), broken percentage (0.207*) and yellow grains percentage (0.302*). However, moisture was negatively correlated with temperature (-0.401).**

Keywords: rice storage, aeration ,circulation,physical, properties

INTRODUCTION

Rice is one of the most important crop in Egypt. The area planted with different types reached about 1.4 million feddan in 2014 (MOALR, 2014). The total grain yield in the same year was about 3.91 million tons of raw paddy rice. Most of the harvested paddy was delivered for rice milling companies for processing. During the processing period, rice was stored using different storage methods, such as packing in jute bags and kept in open such as sheds or warehouses, or stored as bulk in bins. Since paddy grains are harvested with moisture content too high for safe storage, modern bulk storage facilities suffer from serious problems with moisture migration and condensation, increase of temperature within stored paddy, which cause losses in quality of stored paddy as high as 35% (Chrastil, 1990, Hamaker *et al*., 1993 and Park *et al*., 2012). Elevated humidity and temperature in storage bins enhance the infection with fungi, such as moulds, and infestation with insect, which affect the quality of stored paddy and increase losses during processing (Sabra *et al*., 1986 and Arthur 1994). Several methods were suggested to overcome the problems of paddy bulk storage. Aeration for different periods of times is a generally accepted practice for maintaining the quality of stored paddy grains (Kunze, 1984 and Colderwood *et al*., 2004). This investigation was carried out to study the effect of different aeration treatments on quality characteristics of bulk stored paddy rice over a period of six months.

MATERIALS AND METHODS

This study was carried out at the Rice Technology Training Centre, Alexandria, Egypt for a period of six months, starting 15Feb 2015. The rice cultivar used in this study, was Sakha 105, a short - grained japonica type, and the amount of paddy needed for this experiment was provided from the harvested crop of 2014.

Four metal bins, each of 5 tons capacity, were used to study three aeration treatments as follows:

i- No aeration (control) in which the paddy was kept in a closed bin throughout the period of experiment.

Ii-Aeration every two weeks, using a 2.40 m^3/h centrifuge fan for two hours duration at noon time.

Iii-Circulation in which the paddy was transferred between two bins, using a 1 t/h bucket elevator, every two weeks.

Every bin was divided into three sections, i.e. upper, middle and lower.

Samples were randomly taken from each section using a 100 cm sampler.

Samples, each weighing 2 kg, were sealed in plastic bags and the following technical and quality characteristics were rapidly measured:

1) Moisture content (%): Determined using an infra-red instrument Model F-1A (AOAC, 1990).

2) Temperature (°C): It was determined using a thermo cable net installed in each bin.

3) Thousand grain weight: Determined as an average of three 1000 grain samples taken from each section using grain counter model KY-131.

4) Cracked grains (%): This percentage was determined by counting the cracked grains in a random sample of 100-grains placed on a mirror board MK-300.

[1]Rice Technology Training Center, Field Crop research Institute, Agriculture Research Center, Egypt.
Received November 03,2017, Accepted November 28, 2017

5) Bran and germ (%): Determined by whitening a sample of 100 g of cargo rice using a whitening machine type Satake TMO5.

6) Broken (%): Calculated from whitening a random sample of 100 g of cargo rice, using a whitening machine, type Satake TMO5, for two minutes. Whitening was carried out , using a carborandum stone roller, grade No.36.

7) Yellow grains (%): Determined by visual separation of yellow grains from a random sample of 100 g of milled rice.

8) Damaged grains (%): Determined by visual separation of black or brown spotted grains from a random sample of 100 g of milled rice.

9) Husk (%): Determined by dehusking random a sample of 100 g paddy rice using a lab rubber paddy husker, type Satake THU35A.

10) Dead and live insects: Calculated by counting the number of dead and alive insects in a random sample of 100 g of paddy rice, then expressed as the number per kilogram of paddy rice.

Analysis of Data

Statistical analysis of data was carried out as a factorial experiment in one replication. First order interaction aeration treatments X sections was used as an error term to test differences in both aeration treatments and sections factors, whereas the second order, 3-factor interaction, was used as an error term to detect variations with intervals and its first order interactions.

The analyses were carried out, according to Cochran and Cox (1957).

RESULTS AND DISCUSSION

The analysis of variance, for the studied characters, is presented in Table (1).

The data indicated that aeration treatment, i.e. no aeration (control), aeration and circulation, had significant effects on 1000-grain weight, cracked grains percentage and broken grain percentage. The sampling sections i.e., upper, middle and lower sections of each silo, significantly affected percentage of moisture content, temperature and number of dead and alive insects found in each section.

All studied characters, except for cracked grains percentage, were significantly affected by sampling date expressed in the form of a sampling interval of two weeks between samples for a period of 24 weeks (i.e. 12 intervals). The analysis, also, indicated that the studied characters, except for yellow grains percentage (Phillips *et al*., 1988 and Shuo *et al.*, 2014) damaged grains percentage (Zhou *et al*., 2002) and number of dead insects (Arthur, 1994) were affected significantly by one or another of the first order interactions (aeration treatments X intervals or sections X intervals). This shows that the factors included in this study did not affect the measured traits independently, whereas the insignificance of these interactions indicated the possibility of studying the effect of each individual factor, on studied characters, independent from the two other factors.

Moisture content, temperature and storage duration were the most important factors affecting the technological characters of stored rice (Indudhara *et al*., 1978 and Gough *et al*., 1987). Means of studied characters, as affected by aeration treatments, section and storage intervals are presented in Tables 2, 3 and 4, respectively.

The data in Table (2) indicated that both circulation and aeration had significantly higher 1000 grain weight than the control. In addition, circulation tended to have a higher percentage of cracked grains, as well as broken kernels than the control.

With regard to the other studied characters, differences among treatments were insignificant, though there was a trend indicating that aeration and circulation tended to have higher percentages of yellow grains, damaged grains and number of dead insects than the control. Colderwood *et al*. (2004), in an investigation to determine the effectiveness and limitation of aeration for maintaining the quality of rough rice in long-term storage, concluded that control of stored-grain insects was the most important factor in successful long-term storage of rough rice. They, also, pointed out that aeration maintained stored rice at cooler temperature than under non-aeration conditions.

Means of studied characters presented in Table (3) indicated that the upper section of the silo had a significantly higher moisture content, lower temperature, higher number of dead and alive insects compared to the lower section. The higher moisture could be attributed to the, unexpectedly, high precipitation rate during the period of experiment which caused wetting of the upper section of the silo due to water infiltration into the silo. Gough *et al*. (1987) added several explanations for higher moisture content at the top surface of the silo, compared to other locations, which included respiration moisture, rising by air convection, from insects in the rice bulk, humid ambient air entering the silo head scopes, and moisture from the interior of the rice bulk rising by air convection to the top surface.

The other studied characters showed insignificant differences among the different sections of the silo, although the upper section tended to have a higher percentage of yellow grains,

Table 1. Mean squares of studied characters

S.O.V.	D.F.	Moisture %	Temp. °C	1000 grain Weight (g)	Cracked grain%	Bran & germ%	Broken %	Yellow grain%	Damaged grain%	Husk %	Dead insects%	Live insects No.
Aeration treatment	2	0.01	0.007	0.816*	165**	0.148	49.94*	0.237	0.37	0.434	0.466	1.483
section	2	4.33*	10.36*	0.006	9.75	0.168	12.5	0.665	0.454	0.000	2.841*	21.96*
Aeration treatment x sections	4	0.292	1.024	0.088	5.569	0.064	3.562	0.181	0.318	0.445	0.171	1.588
Intervals	11	5.781**	61.34**	1.248**	39.33	18.48**	7.961*	0.347**	0.583**	0.88*	12.83**	83.79**
Aeration treatment x Intervals	22	0.389	0.987	0.328**	93.73*	0.521*	6.002*	0.112	0.206	0.511	1.779	3.283
Section x Intervals	22	2.877**	2.159*	0.083	53.78	0.151	2.795	0.137	0.183	0.674*	0.599	7.622**
Silos X Sections X Intervals	44	0.408	0.951	0.061	44.43	0.264	3.02	0.127	0.169	0.361	1.682	2.976

*,**: Significant at 0.05 and 0.01 levels of significance

Table 2. Means of studied characters as affected by different aeration practices

Characters / Aeration treatment	Moisture %	Temp. °C	1000 grain Weight (g)	Cracked grain%	Bran& germ%	Broken%	Yellow grain%	Damaged grain%	Husk%	Dead insects No.	Live insects No.
Control	13.26	26.38	23.31	16.19	9.69	4.39	0.60	0.66	18.67	1.64	3.64
Aeration	13.29	26.39	23.57	16.22	9.79	5.89	0.75	0.83	18.46	1.96	3.90
Circulation	13.29	26.40	23.39	19.92	9.68	6.71	0.73	0.85	18.5	1.89	3.50
$L.S.D._{0.05}$	N.S	N.S	0.19	N.S	N.S	1.24	N.S.	N.S.	N.S.	N.S.	N.S

N.S. : Not significant

Table 3. Means of studied characters as affected by different silos sections

Characters / Sections	Moisture%	Temp. °C	1000 grain Weight (g)	Cracked grain %	Bran & germ%	Broken %	Yellow grain %	Damaged grain%	Husk%	Dead insects No.	Live insects No.
Upper	13.56	25.92	23.49	17.28	9.8	5.52	0.85	0.82	18.55	2.08	3.72
Middle	12.96	26.28	23.51	17.03	9.7	6.31	0.6	0.62	18.24	1.96	4.43
Lower	13.24	26.97	23.84	18.03	9.6	6.16	0.63	0.84	18.54	1.55	2.88
$L.S.D._{0.05}$	0.35	0.66	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.27	0.83

N.S. : Not significant

Table 4. Means of studied characters as affected by storage intervals

Character / Intervals	Moisture %	Temp. °C	1000 grain Weight (g)	Cracked grain%	Bran & germ%	Broken%	Yellow grain%	Damaged grain%	Husk%	Dead insects No.	Live insects No.
1	13.36	25.22	23.17	21.44	7.91	4.62	0.64	0.82	18.06	0.96	0.80
2	12.2	26.78	23.07	17.78	7.88	5.29	0.90	1.04	18.11	0.96	0.70
3	12.10	25.89	23.64	17.67	8.21	4.88	0.53	0.55	18.68	0.95	1.21
4	13.24	28.22	23.62	16.67	8.37	4.82	0.50	0.60	18.34	1.00	1.40
5	12.88	27.44	23.67	17.11	8.40	4.57	0.39	0.34	18.54	1.00	1.57
6	12.33	26.78	23.47	17.78	10.94	4.60	0.59	0.52	19.10	1.42	2.25
7	13.17	27.44	23.06	17.56	11.19	6.80	0.73	0.77	18.47	1.45	3.94
8	13.14	26.56	23.30	13.56	10.47	6.48	0.60	0.62	18.34	2.85	3.54
9	12.96	29.00	23.31	19.56	10.83	6.58	0.61	0.90	18.71	4.21	4.28
10	13.68	30.00	23.22	19.11	11.14	6.33	0.95	1.06	18.79	2.73	7.83
11	15.33	22.89	24.07	16.44	11.06	6.82	0.87	0.99	18.47	1.08	10.09
12	14.00	20.44	24.22	14.67	10.24	6.18	1.01	1.14	18.92	3.73	6.63
L.S.D	0.61	0.93	0.23	N.S	0.49	1.65	0.34	0.39	0.57	1.23	1.64

N.S. : Not significant

Table 5. Simple correlation coefficients between pairs of studied character

Character	Moisture %	Temp. °C	1000 grain Weight (g)	Cracked grains %	Bran & germ%	Broken%	Yellow grains%	Damaged grains %	Husk%
Moisture %	- -	0.401**-	0.310**	0.095	0.224*	0.207*	0.302**	0.302**	0.170
Temp.°C		- -	0.448**-	0.061	0.027	0.084	0.215	0.162	0.009
/g weight 1000	- -	- -	- -	0.077	0.066	0.136	0.012	0.007	0.072
Cracked grain %	- -	- -	- -	- -	0.016**	0.281	0.052	0.085	0.119
Bran & germ %	- -	- -	- -	- -	- -	0.311**	0.203	0.155	0.254**
Broken %	- -	- -	- -	- -	- -	- -	0.224	0.195*	0.026*
Yellow grain %	- -	- -	- -	- -	- -	- -	- -	0.726	0.145**
Damaged grain %	- -	- -	- -	- -	- -	- -	- -	- -	0.165

:Significant at 0.05 and 0.01 levels of significance **,* compared to the middle and lower sections. The middle section gave the highest values for broken percentage. Such results clearly emphasizes the necessity to draw random samples from different sections of the silo in order to have a correct diagnosis of the stored paddy in the silo .Drawing samples from one level only for laboratory assessment, would result in misleading information about the conditions of stored paddy.

Data presented in Table (4) indicated that there was no fixed trend for the effect of storage interval on most of the studied characters except for broken percentage and number of dead and alive insects whereas, means of all other measured traits fluctuated, significantly or insignificantly, with elongation of storage period (Villareal *et al*., 1976 and Daniels *et al.*, 1998). On the other hand, the three former traits increased with increasing storage duration. The increase was noticed starting from the seventh interval. Park *et al* (2012) noticed that the average moisture content of aerated bulk of rice decreased from an initial moisture content of 20 to 12.5% in seventy days, but, after 180 days of storage, the average moisture content increased up to 13.0 % . On the other hand, the average moisture content of non-aerated bulk decreased slightly from 17.0 to 15.0 %, in a period of 160 days, then, increased significantly. The average temperature of the bulk was close to the ambient for about 150 days storage and, then, started to increase. The average temperature reached a value of 30 ˚C, compared to an ambient temperature of 23.5 ˚C. The maximum grain temperature reached 43 ˚C after 180 days. They concluded that such high temperature was a result of self-heating. Also, Gough *et al*. (1987) indicated that bulk temperature fluctuated in response to ambient air temperature and that aeration of bulk rice caused the temperature to decline with the diurnal minimum ambient air temperature.

Simple correlation coefficients between pairs of studied characters, are presented in Table (5). The data indicated that moisture content was significantly correlated with all characters except for cracked grains percentage and husk percentage. The correlation between moisture content and studied characters was also found to be positive, except for temperature where relationship was negative.

Temperature was negatively and highly significantly correlated with 1000 grain weight and yellow grains percentage.

Cracked grains percentage was positively and significantly correlated with bran and germ. Bran and germ percentage was found to be significantly and positively correlated with broken and husk percentage. Besides, broken percentage was positively and significantly correlated with both damaged grains and husk, whereas yellow grains percentage was positively and highly significantly correlated with husk percentage.

These results emphasize the role of temperature and moisture content of grains as important factors affecting the milling quality of rice stored in bulk. Nguyen *et al*. (2009) emphasized the importance of those two factors and their effect on technological characters of stored rice.

REFERENCES

AOAC. 1990. Official Methods of Analysis of Association of Official Agricultural Chemistry. 11 th edition. Washington D.C.

Arthur, F. H. 1994. Feasibility of using aeration to control insect pests of corn in Southeast Georgia: Simulated field test. J. Econ. Entomol. 87:1359-1365.

Chrastil, J. 1990. Chemical and physiochemical changes of rice during storage at different temperatures. J. Cereal Sci. 11: 71-85.

Cochran, W.G.and G.H.Cox. 1957. Experimental Designs 2nd ed. John Willy & Sons Inc. New York, USA.

Colderwood, D.L., R.R. Cogbarn, B.D. Webb, M.A. Marchetti. 2004. Aeration of Rough Rice in Long Term Storage. Transaction of the AS.AE. 6: 1579-1585.

Daniels, M.J., B.P. Marks, T.J. Siebenmorgen, R.W. Mcnew and J.F. Meullenet. 1998. Effects of long-grain rough rice storage history on end-use quality. Journal of food Sci. 63(5): 832-835.

Gough, M.C., H.S. Cheigh , S.K. Kim ,T.W. Kown. 1987. Physical Changes in Stored Bulk Rice, J.Agric. Engineering Res. 37:59-71

Hamaker, B.R., T.J. Siebenmorgan and R.H. Dilday. 1993. Aging of rice in the first six months after har- vest. Arkansas Farm Res. 42(1): 8-9.

Indudhara, S. Y. M., C. M. Sowbhagya, K. R. Bhattacharya. 1978. Changes in physicochemical properties of rice with aging. J. Sci. Food Agric., 29, 627-639.

Kunze, O. 1984. Physical properties of rice related to drying the grain. Drying Technol. 2: 369-387.

MOALR. 2014. The Annual Report of the national Campaign of Rice. Ministry of Agriculture Acad. Sci., Res. and Techn. 100.

Park, Chan-Eun, Yun-Sook Kim, Kee-Jai Park, Bum-Keun Kim. 2012. Changes in physicochemical characteristics of rice during storage at different temperatures. J. Stored Prod. Res. 48: 25-29

Phillips, S., S.Widjaja, A.Wallbridge, R. Cooke. 1988. Rice Yellowing During Post Harvest Drying By Aeration and During Storage. J. Stored Prod. Res.24(3): 173-181.

Sabra, M. A.,A.Z. Shoukr and S.M. Ismail. 1986. Moisture and temperature changes of paddy rice in different storage system in Egypt. Third Int. Rice Conf. Alex., Egypt.

Shuo Qiu, S. Kawamura, S. Fujikawa and T. Doi. 2014. Long-term storability of rough rice and brown rice under different storage conditions. Engineering in Agriculture, Environment and Food. 7(1): 40-45.

Villareal, R. M., A. P.Resurreccion, L. B. Suzuki, B. O. Juliano. 1976. Changes in physicochemical properties of rice during storage. Starch. 28:88-94.

Zhou, Z., K.Robards, S. Helliwell, C. Blanchard. 2002. Aging of stored rice: changes in chemical and physical attributes. J. Cereal Sci. 35:65-78.

الملخص العربي

تأثير التهوية والتقليب على الأرز الشعير المخزن صبا

دعاء احمد انورعبد الباري، احمد رمضان ابراهيم خطاب

يهدف هذا البحث الى دراسة تأثير كل من التهوية والتقليب على الأرز الشعير المخزن صبا فى صوامع معدنية. وقد تولدت الفكرة بعد زيادة الاهتمام بإدخال نظم التخزين صبا فى صوامع معدنية مثل صوامع القمح والارز الشعير دون الاخذ فى الاعتبار حساسية الارز الشعير وتأثرة بفترة التخزين وارتفاع الصومعة مع استخدام بعض الوسائل التى تساعد على الحفاظ على نوعية الارز الشعير مثل التهوية باستخدام مروحة محورية اوتقليب الارز.

وقد تناول البحث دراسة مواصفات الأرز المخزن من حيث النسبة المئوية للرطوبة، وزن الألف حبة، نسبة الكسر والنسبة المئوية للحبوب الصفراء، والنسبة المئوية للحبوب التالفة، ونسبة الإصابة الحشرية بالحشرات الحية والميتة.

وقد إظهرت النتائج وجود فروق معنوية للصفات الطبيعية للأرز الشعير المخزن عند التهوية وفترة التخزين وارتفاع عامود الأرز الشعير خاصة فى درجة حرارة الآرز والنسبة المئوية للرطوبة وقد أدى استخدام التهوية الى تقليل الإصابة الحشرية مما يؤدى الى الحفاظ على نوعية الأرز الشعير خلال فترة التخزين.

وأظهر تحليل التلازم البسيط وجود إرتباط معنوى بين عديد من الصفات تحت الدراسة. حيث ارتبطت نسبة الرطبوة ارتباطاً معنوياً موجباً مع كل من وزن ١٠٠٠ حبة (٠،٣١٠*) ونسبة الردة والجنين (٠،٢٢٤*) ونسبة الكسر (٠،٢٠٧*) ونسبة الحبوب الصفراء (٠،٣٠٢**) فى حين ارتباطن نسبة الرطوبة ارتباطاً معنوياً سالباً مع درجة الحرارة (-٠،٤٠١**).