Feasibility of long term bulk paddy storage method for local conditions

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Abstract- *a study was conducted to evaluate the feasibility of silo method for long term bulk paddy storage and the effect on grain quality during storage period. A hopper bottom type meal silo of seven ton capacity was used for the experiment. As the control experiment, paddy was stored in 50 kg polysack bags. Freshly harvested properly cleaned and dried paddy was loaded to silo for the storage trial. The experiment was conducted for six months of period at 30°C ± 4 of ambient temperature and 67% ± 5 of relative humidity. Temperature, relative humidity readings. Moisture contents of paddy grains were measured at initial stage, once a week during the storage period, and final stge. Insect damages, milling qualities and thousand grain mass were determined at monthly intervals. The ambient and inside temperature ranged within 8 °C to but there was no significant difference (p=0.05) of temperatures in outside and inside the silo. Relative humidity during six months period fluctuated by 10% that did not any effect on the grain moisture content. The grain moisture content at the store period slightly changed within 1.2%. The degree of insect damage to grains increased in both silo and controls along storage period. The mass loss due insect infestation was 40% lower in paddy samples drawn from silo than that of bags during storage. The total milling yield and head rice yield of paddy had reduced during the storage period in both silo and control experiment. Thousand grain mass of paddy stored in silo had changed by 3g while this was 5g in control. Silo system can be used for long term paddy storage under local conditions.*

Keywords*— Paddy, Silo, Bulk Storage, Quality*

I. INTRODUCTION

Rice is the staple food in Sri Lanka and it is produced in two seasons per year. Providing food security for times of scarcity, effective paddy storage is an inflation-proof savings bank. But in Sri Lanka, most significant grain loss in the post-harvest stages occurs during storage, and is caused by the lack of suitable storage facilities and absence of storage management technologies at farmer level and large scale level as well (Wijerathne*et al*., 2009).

Wholesalers and millers handle a substantially large volume of paddy than farmers, assemblers and middlemen and their storage facilities are correspondingly larger. The number of wholesalers is generally small and distributed throughout the regional townships and principal cities in paddy producing areas. They are currently practicing bag storage system which requires more labour, land area and bags. In fact, researchers have indicated that post-harvest losses are comparatively higher in conventional bag storage system (Gunathilake *et al*., 2014). There is the possibility that private investors and public paddy purchasing bodies will establish commercial paddy storage facilities for handling in bulk. One of the common bulk storage methods used in the world is silo system, which is rarely used in Sri Lanka. The advantages of silos are low storage loss and handling cost, and silos can be linked directly to automated commercial level rice mills. Further, this system saves manual labour, which is difficult to obtain in the peak seasons of harvesting and procurement. Approximately Rs. 800 million valued amount of paddy can be saved annually by reducing only 1% of grain loss during storage. Therefore, this study was conducted to evaluate the feasibility of silo system for bulk paddy storage to ensure the food security in the country throughout the year.

II. MATERIALS AND METHODS

A .Preparation of the silo for the experiment

The experiment was conducted at the bulk grain storage complex of Institute of Post Harvest Technology, Anuradhapura, Sri Lanka. A hopper bottom type metal silo with 7- metric ton capacity was repaired and modified to carry out the storage experiment. An elevator for mechanical loading of grains was fixed to the silo.Eighteen thermocouples were fixed at different place in the silo to collect inside temperature data and 2 inch pvc pipes with small holes were set at different levels in the siloto measure inside relative humidity (RH) during the experiment period. A new air blower of 1200 cfm was fixed to the silo for aeration to reduce the inside temperature, accumulation of high inside moisture and prevent forming of hot spots in the bin.

B. Storage experiment

Eight tons of paddy (long grain white) harvested during yala season 2013 were purchased form Paddy Marketing Board for the experiment, and the obtained paddy lot was properly cleaned and dried to about 14% moisture content. The silo was loaded with seven tons of paddy for storage trial. As the control experiment, one metric tons of paddy from same source was stored in 50 kg polysack bags at the IPHT warehouse. The experiment was conducted for six months of period where the ambient temperature was 30 °C ± 4 of and relative humiditywas 67% ± 5. Composite paddy samples were collected before storage from the paddy lot purchased, at monthly intervals during the storage period and end of the storage period. Paddy samples were drawn from different places of silo to represent top, bottom, centre and sides. From each sampling point, three replicates of paddy were collected. Phosphine fumigations were carried out for the paddy at the silo and control samples to destroy all kinds of insects.

C. Data collection and quality analysis

Ambient temperature and relative humidity were recorded daily using digital thermometer and digital hydrometer. These readings were recorded inside the silo and paddy bags at weekly intervals. Inside temperature and RH of silo measuring points were located as indicated in figure1.

Moisture contents of paddy samples at initial stage, at end of the storage period and during the storage at different places of the silo as shown in the figure 1 were measured weekly according to the AOAC method.

Other grain quality parameters were measured at monthly intervals during the storage period other than initial and final stages of the experiment. The 1000 kernels of paddy sample were counted using a grain counter and weighed to determine thousand grain mass (TGM).

Insect-damaged kernels were separated from undamaged kernels in a sample of 50 g of paddy. Number and weight of damaged and undamaged kernels were also recorded, and mass loss due to insect damage was determined using the following formula;

$$\text{Mass loss due to insect damage} = \frac{UNd - DNu}{U(Nd + Nu)} \times 100\%$$

Where, Nd - Number of insect damagedgrains, D - Weight of insect damaged grains, Nu - Number of undamaged grains, U - Weight of undamaged grains

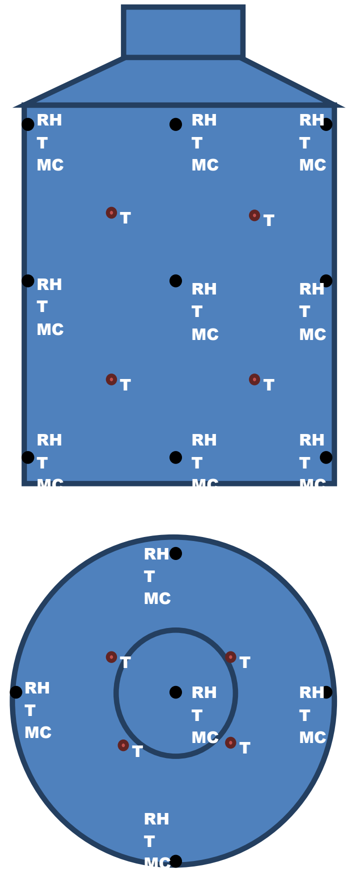

Figure 1: Sample and data collection poins of the silo RH:relative humidity, T:temparature, MC:moisture content

Pre-cleaned paddy samples were passed twice through a laboratory rubber role sheller (Model: Satake) for dehusking. This resulted brown rice was polished removing 7.5-8% of bran layer using laboratory scale abrasive polisher (Model: 2TX Mc Gill). Then, broken grains of milled rice were separated considering at least two-third of original kernel length as head. Total milling yield (TMY) and head rice yield (HRY) were calculated using following formula,

$$Total\ Milling\ \ Yield = \frac{Weight\ \ of\ polished\ \ rice}{Weight\ \ of\ \ paddy} \times 100\%$$

$$Head\ Rice\ \ Yield = \frac{Weight\ \ of\ head\ \ rice}{Weight\ \ of\ \ polished\ rice} \times 100\%$$

D. Data analysis

Data gathered were analysed using Analysis of Variance (ANOVA) by Statistical Analysis System (SAS). Differences among treatment means were obtained by Duncan's multiple range tests at 5% significance level.

Every day, at mid time and evening, loaded paddy in the silo was aerated using the air blower fixed to the silo for half an hour to remove the excess water vapour in the silo.

III. RESULT AND DISCUSSION

Variation of environmental conditions

Inside and outside temperature during the storage period is shown in figure 2.

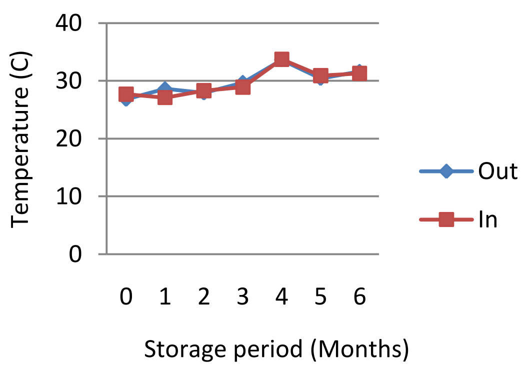

Figure 2: Temperature changes during store period

During storage period, temperature of both inside and ambient varied from 26 ^{0}C to 34 ^{0}C but there was no significant difference (p=0.05) of temperatures in outside and inside the silo. Proper silo management practices can maintain the inside temperature evenly and close to ambient conditions. Relative humidity of atmosphere and among paddy grains in the silo is presented in this figure 3.

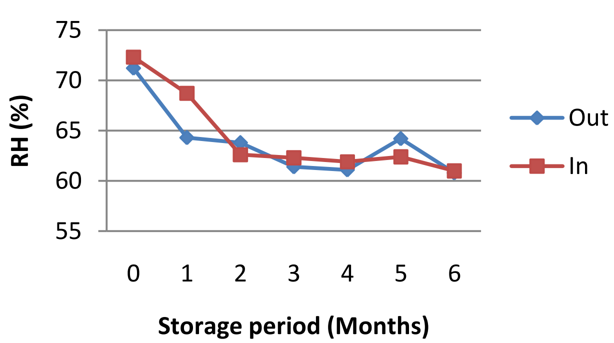

Figure 3: Changes of RH during store time

During first two months of storage period, inside RH of silo was higher than to atmosphere. But after that RH of atmosphere and inside followed same pattern and did not show any difference. RH varied during the six months from 62% to 72%. This range does not any effect on the grain moisture content.

Grain moisture content

Moisture content of stored paddy grains of silo and control during the storage period is shown in figure 4.

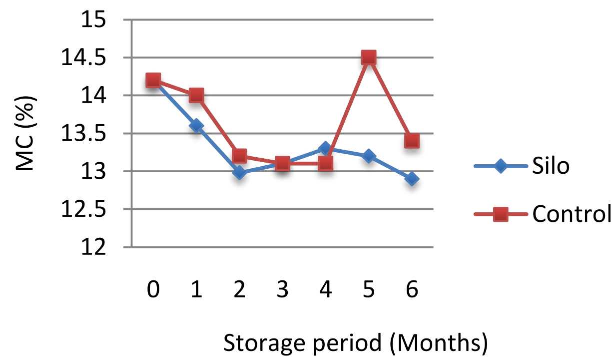

Figure 4: Changes ingrain moisture content

Moisture content of grains in the experimental period existed between 13 – 14.5% which is favourable to store grains. Although moisture content at loading time was 14%, after two months it reduced up to 13% and remained between 13 – 13.5% on the silo. According to Hengsadeekul and Nimityongskulthe (2004), high temperature and aeration had effected on moisture reduction.

Insect infestations

The mass loss of paddy grains due to insect damages stored in silo and bags are presented in table 1.

Table 1: Mass loss due to insect damage of paddy grains during the storage

	Mass loss (%)						
	Initial	1	2	3	4	5	6
Silo	0.8^{a}	0.8^{a}	0.9^{b}	1.0^{b}	1.0^{b}	1.5^{b}	1.6^{b}
Control	0.8^{a}	0.9^{a}	1.3^{a}	1.4^{a}	1.8^{a}	2.1^{a}	2.7^{a}

Values with same letters in columns are not significantly different (p=0.05)

As indicated in the table, the degree of insect damage increased in controls after two months while the level of insect damage to paddy grains in silo started to increase considerably after four months. The mass loss due to insect infestation was significantly higher (p=0.05) in paddy samples drawn from bags than that of silo during storage. In addition, few insect types; mainly rice weevil (*Sitophilsoryza*) and lesser grain borer

(*Rhysoperthadominica*) were found in paddy samples drawn from both bags and silo. Food and Agriculture organization (FAO, 2016) in 2014 also reported that these two insect types are common among stored paddy in Sri Lanka. This result clearly showed that storing of the paddy in silo can reduce the insect infestations.

Milling and grain qualities

Total Milling Yield (TMY) & Head Rice Yield (HRY) of paddy during the storage period are shown in figure 5 and 6.

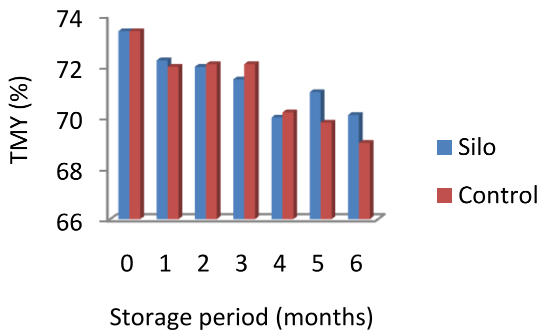

Figure 5: Total milling yield of paddy

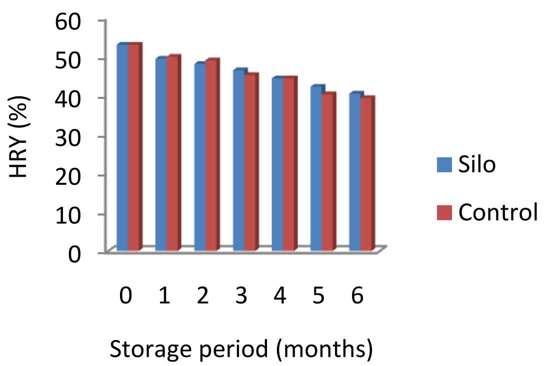

Figure 6: Head rice yield of paddy

The TMY and HRY of paddy had reduced during the storage period in both silo and control experiment. But the rate of changing of these properties was considerably lower in silo compared to the bag storage at conventional warehouse system. Insect infestations directly cause comparative lower TMY and HRY of paddy during storage (Adikarinayake, 2005).

Thousand grains mass (TGM) of paddy samples stored in silo and bags during the experiment period is shown in figure 7.

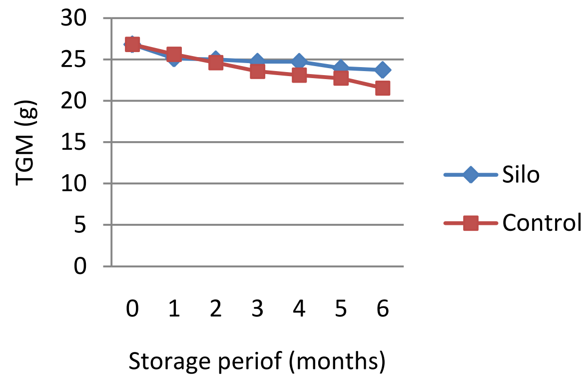

Figure 7: Changes of TGM during store period

TGM of paddy stored in silo had changed from 27 g to 24 g while this was from 27 g to 22 g in control experiment. After two months of storage period, reduction of TGM of paddy stored in bags was higher than that of paddy stored in silo.

IV. CONCLUSION

Paddy can be stored in silos for six months while maintaining comparatively lower insect infestations and quality deteriorations under local conditions. Aeration of silo is effective in maintaining the grain moisture and inside relative humidity at safe range.

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