Assessment of Dry Mass Loss of Stored Cereals Due to Increment of Stored Temperature in Line with Global Warming

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Abstract: ***To monitor respiratory climacteric behavior of grains due to global warming, a study was conducted using paddy, green gram, corn and cowpea at initial moisture contents of 10.9%, 8.6%, 8.9% and 10.6% respectively. These grains were packed in gunny and poly sack bags in 5kg separately and placed in four temperature controlled insulated chambers where inside temperatures were maintained at 4^0, 27^0 (Ambient), 35^0, 40^0 & 45^0C respectively. Thereafter, moisture content and 1000 grain weight of each commodity were taken for every 15 days intervals with three replicates in order to calculate dry matter loss against period of storage, stored temperature and type of packing materials. After 4 months of storage, the dry matter loss of paddy in poly sacks and gunny at 4^0, 27^0, 35^0, 40^0 & 45^0C temperatures were 3.07%, 4.46%, 5.38%, 5.30%, 5.61% and 2.35%, 2.54%, 4.03%, 4.72%, 5.22% respectively. In the case of corn these losses were 6.69%, 6.80%, 6.89%, 8.35% and 9.22% and, 7.12%, 7.12%, 7.76%, 8.88% and 9.89% respectively. For green gram, they were 6.42%, 6.76%, 7.03%, 6.78%, 6.90% and 6.44%, 7.40%, 7.79%, 7.41%, 7.31% respectively and for cowpea which was 4.22%, 8.96%, 9.17%, 9.26%, 9.63% and 5.97%, 9.91%, 9.99%, 10.17%, 11.22%. Since, dry matter loss of paddy, green gram, corn and cowpea were occurred on 3 variables, a regression analysis was performed to formulate a quantified relationship. Paddy stored in gunny bags shows less dry mass loss because; thick seed coat of paddy acts as a heat insulator and contributes to accumulate heat during respiration. Hence, paddy needs a porous type of packing material like gunny to flush out buildup heat. Whereas, other types of grains need tight and less porous packing like poly sack to prevents direct contact of atmospheric oxygen with thin seed coat which facilitates to high rate of respiration.***

Keywords: Global Warming, climacteric behavior, Dry matter loss, Poly sack, Gunny, Paddy, Greengram, cowpea, corn

1. Introduction

Global Warming is the increasing of Earth's average surface and atmospheric temperature due to effect of greenhouse gases emissions from burning fossil fuels while carrying out of deforestation at an alarm level. Combine consequence of these ill-fated activities, carbon dioxide level in the atmosphere is alarmingly increased and as a result of that, solar radiation reflect back to the atmosphere. Since the early 20th century, Earth's mean surface temperature has increased by about 0.8^0C, with about two-thirds of the increases occurring since 1980 *(Houghton et al., 1990)*. Sri Lanka is situated in the tropical belt of the globe and she usually experienced with a warm tropical climate, along with average yearly temperature variation from 28^0C to nearly 31°C. Analysis of data on temperature from 1960 to 2001 has shown that annual temperature rise in Sri Lanka is about 0.016 ^{0}C (2.6 ^{0}C / 100 years). *(Basnayake et al., 2008; Zubair et al., 2008)*. Nevertheless, due to global warming the ambient air temperature can be raised more than 33 ^{0}C within next 100 years of period.

Cereal grains have been the principal component of human diet for thousands of years and have played a major role in shaping human civilization. Around the world, rice, wheat, and corn, and to a lesser extent, sorghum and finger millets are important staples critical to daily survival of billions of people. *(Joseph, 2011)* The post harvest losses of grains during storage will be a challenging issue in the future, because these losses are associated with the controllable and uncontrollable variables. Global warming and increment of corresponding rate of respiration are the main uncontrollable variables which may cause for loosing of grain's dry mass quantitatively as well as qualitatively inadvertently. Therefore, aim of this study was to quantify the dry mass loss of selected grains, packed in different packing materials and stored in different temperatures for a period of 4 months.

2. Methodology

Five types of freshly harvested grain namely paddy, green gram, corn and cowpea were taken and dried to get the safe moisture contents below 14% for paddy and 12% for other grains. Thereafter, these grains were packed in 5kg in gunny bags and poly sacks separately and placed in five temperature controlled insulated chambers. The chambers were equipped with an electrical device to maintain the stipulated temperatures of 4^0, 27^0 (Ambient), 35^0, 40^0 & 45^0C. Thereafter, samples were drawn from each commodity for every 15 days intervals for a period of 4 months and subjected to determine, moisture content, and 1000 grain weight as these two parameters are required to calculate dry mass loss of the grains as against period of storage, type of packing material and stored temperature. In calculation of dry mass loss, the methods described by *Jim Reeb,1999-May* for moisture, *White and Saddik, 1983* for germination and *Hossein Afshari, 2011-August* for 1000 grain weight were taken into account.

2.1 Establishment of a relationship between dry mass loss of paddy as against period of storage, types of packing material and stored temperature

To establish a relationship between dry mass loss of paddy, Green gram, Corn and Cowpea as against stored temperature, type of packing material and period of storage, a regression analysis was performed for each grain. If

coefficient of co- relation is equal to a value in between 0.75-1.0, there is a positive correlation ship between dry mass loss and the stipulated three variables. In order to quantify this relationship by an equation, further analysis was carried out based on the method described in the regression analysis.

2.2 Drawing contour plots to present the data in graphical manner

To present the outcome of the study in a graphical manner, contour plot was drawn which depict the relationship between dry mass loss of the grain as against period of storage and stored temperature. This plot is very important because user can assess the loss by just glancing at it and it can also be co-related to the dry mass loss due to global warming.

3. Results and Discussion

1000 grain weight and corresponding moisture content pertaining to the period of storage, type of packing materials and stored temperature were used to calculate dry mass loss of paddy. Results are given in table 1.

Table 1: Total Dry mass loss of paddy with different stored temperatures, different packaging materials and period of storage

	Paddy									
	Cold (4^0C± 2^0C)		(27^0C±2^0C)		35^0C± 2^0C		40^0C± 2^0C		45^0C± 2^0C	
Months	*Poly Sack*	*Gunny*	*Poly Sack*	*Gunny*	*Poly Sack*	*Gunny*	*Poly Sack*	*Gunny*	*Poly Sack*	*Gunny*
0	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
0.5	1.68%	1.38%	3.21%	2.43%	3.52%	2.40%	2.92%	2.33%	3.42%	2.76%
1	1.76%	1.47%	4.01%	2.40%	4.10%	2.84%	4.10%	3.16%	4.74%	3.25%
2	2.27%	2.06%	4.21%	2.61%	5.12%	3.48%	5.23%	3.89%	5.13%	4.15%
3	2.48%	2.09%	4.36%	2.47%	5.24%	3.48%	5.30%	4.05%	5.46%	4.07%
4	3.07%	2.35%	4.46%	2.54%	5.38%	4.03%	5.30%	4.72%	5.61%	5.22%

The data given in the table 1 clearly indicate that total dry mass loss of paddy is increased with the time of storage and occurrence of rate of which at initially higher than that of later. Reason for this consequence is, paddy initially respire at a higher rate than that of later. So also, same trend has been showing that paddy has been stored in different temperatures as well as different packing materials. Moreover, occurrence of dry mass loss of paddy in gunny is lower than that of in poly sack. Thus, it gives an idea, storing of paddy in gunny is better than storing in poly sac. Reason for this phenomenon is, live paddy grains respire and generate CO_2, heat and water vapor as byproducts. The generated heat in the paddy mass itself further accelerates the rate of respiration by utilizing accumulated starch. The same effect was reported by *Carl Reed, et al 2007*. Therefore weight loss of stored paddy is proportionate to the increment temperature in the grain mass itself. However paddy in gunny having a well porous structure that facilitates to flush out accumulated heat through natural air currents, but paddy in poly sack does not have that property and it deprives the natural aeration process badly. Therefore paddy in poly sack shows more mass loss than paddy in gunny bags. Moreover, paddy grain has been covered with a thick husk, which can act as a heat insulator, because paddy husk is a class one insulation material (*Francis, 2009)*. Therefore, considerable amount of accumulated heat due to respiration is retaining in the grain itself due to its heat resistant behavior. Same finding has been observed by *Oliver, 2004* in heat resistant behavior of paddy husk. Hence, stored paddy required a mechanism to facilitate to flush out accumulated heat in the grain itself.

To illustrate this relationship further, a contour plot for dry mass loss was drawn using period of storage verses stored temperature, which is given in Fig: 1.

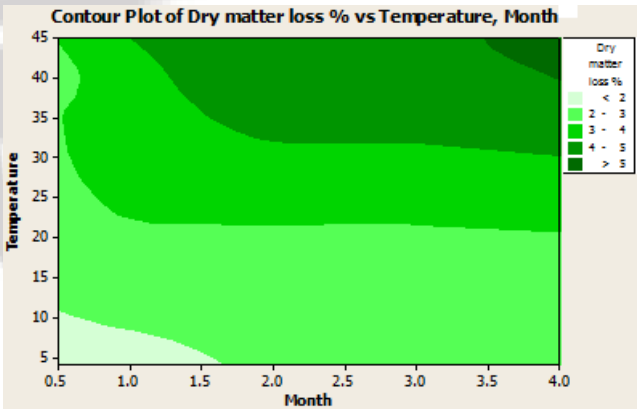

Figure 1: Dry mass loss of paddy as against stored temperature and period of storage

The counter plot also indicates that dry mass loss of paddy having a reciprocal relationship with the stored temperature. Therefore, this plot can easily be used to determine dry matter loss of paddy due to increment of temperature in the stored environment. On the other hand, this plot can be used to predict dry mass loss of paddy due to increment of ambient air temperature as a result of global warming. The dotted line of the plot represents the current average temperature in Sri Lanka.

3.1 Establishment of a relationship between dry mass loss of paddy as against period of storage, types of packing material and stored temperature

The data obtained from the study were subjected to regression analysis and results revealed that there is a strong positive co-relationship between dry mass loss of paddy and other 3 variables as coefficient of co-relation is 0.88. To quantify this relationship a formula was developed based on the method described in the regression analysis.

Dry Matter Loss (Paddy) = 2.49 + 0.0576 T + 0.435D - 1.06 P

P = packing material 1 for gunny and 2 for poly sack, T = storage temp, D = period of storage (Month)

3.2 Total Dry mass losses of green gram, corn and cowpea

Total Dry mass losses of green gram, corn and cowpea under different stored temperatures with different packaging materials as well as period of storage are given in the table 2.

Table 2: Total Dry mass losses in green gram, corn and cowpea under different ambient air temperature with different packaging material as against period of storage

Grain	Months	Cold (4^0 C ± 2^0C)		Ambient(27^0C ±2^0C)		35^0 C ± 2^0C		40^0 C ± 2^0C		45^0 C ± 2^0C	
		Poly Sack	Gunny	Poly Sack	Gunny	Poly Sack	Gunny	Poly Sack	Gunny	Poly Sack	Gunny
Green Gram	0.5	0.28%	1.37%	0.45%	2.82%	0.61%	2.93%	0.63%	3.94%	4.53%	5.26%
	1	3.68%	3.80%	4.08%	4.29%	4.40%	5.83%	4.84%	6.17%	4.89%	6.34%
	2	4.90%	5.16%	6.04%	6.30%	6.06%	6.32%	6.13%	6.44%	6.50%	7.28%
	3	5.09%	6.16%	6.23%	6.32%	6.31%	6.40%	6.38%	6.46%	6.55%	6.76%
	4	6.42%	6.44%	6.76%	7.40%	7.03%	7.79%	6.78%	7.41%	6.90%	7.31%
Corn	0.5	1.58%	2.47%	3.19%	3.19%	4.30%	5.54%	4.98%	6.32%	5.63%	8.20%
	1	2.39%	3.23%	4.08%	4.77%	5.10%	7.30%	5.35%	7.55%	7.15%	8.58%
	2	4.11%	5.43%	5.14%	6.36%	6.01%	7.31%	7.97%	9.12%	8.24%	9.52%
	3	4.85%	5.62%	5.38%	6.63%	6.41%	7.33%	7.77%	8.66%	9.02%	10.04%
	4	6.69%	7.12%	6.80%	7.12%	6.89%	7.76%	8.35%	8.88%	9.22%	9.89%
Cowpea	0.5	0.73%	2.45%	0.90%	4.98%	2.88%	3.95%	3.66%	5.21%	5.52%	5.23%
	1	0.96%	4.92%	5.34%	6.09%	6.46%	6.60%	6.60%	6.61%	6.84%	6.83%
	2	1.60%	5.41%	7.26%	8.43%	7.43%	8.46%	7.49%	8.63%	7.77%	9.20%
	3	3.47%	5.82%	8.98%	9.84%	9.13%	9.60%	9.15%	9.89%	8.96%	9.92%
	4	4.22%	5.97%	8.96%	9.91%	9.17%	9.99%	9.26%	10.17%	9.63%	11.22%

The data given in the table 2 illustrate that total dry mass loss of green gram, corn and cowpea are increased with the period of storage and the rate of dry mass loss at the beginning is higher than that of later as paddy has shown. However, green gram cowpea and corn packed in poly sack show less dry mass loss than that they were packed in gunny bags. Reason for this consequence is rate of respiration; because rate of respiration of these grains in gunny is somewhat higher than that they were in poly sack and this phenomenon is counter to the paddy. Since, these grains do not have a thick protective layer for the endosperm as paddy does, the ambient air particularly oxygen can easily coming into contact with the endosperm. As gunny bags are more porous than poly sack, air permeability of gunny is quiet higher than the poly sac. Hence, gunny bags permit to ingress more atmospheric oxygen into the product.. Therefore, green gram, cowpea and corn need tight packing like in poly sack in order to prevent dry mass loss during storage due to respiration. As Green gram and Cowpea are inherited with a paper thin seed coat, rate of respiration of these legumes is relatively higher and as a result of that viability of the seed decline rapidly (*Wilfred, 1994*). Since, corn also having thin seed coat, polymer coating has been performed in order to enhance field performance and storability (*Hanegave, 2009*)To illustrate this phenomenon further, contour plot of dry mass loss for each grain was drawn as against period of storage and stored temperature which are given in fig: 2.

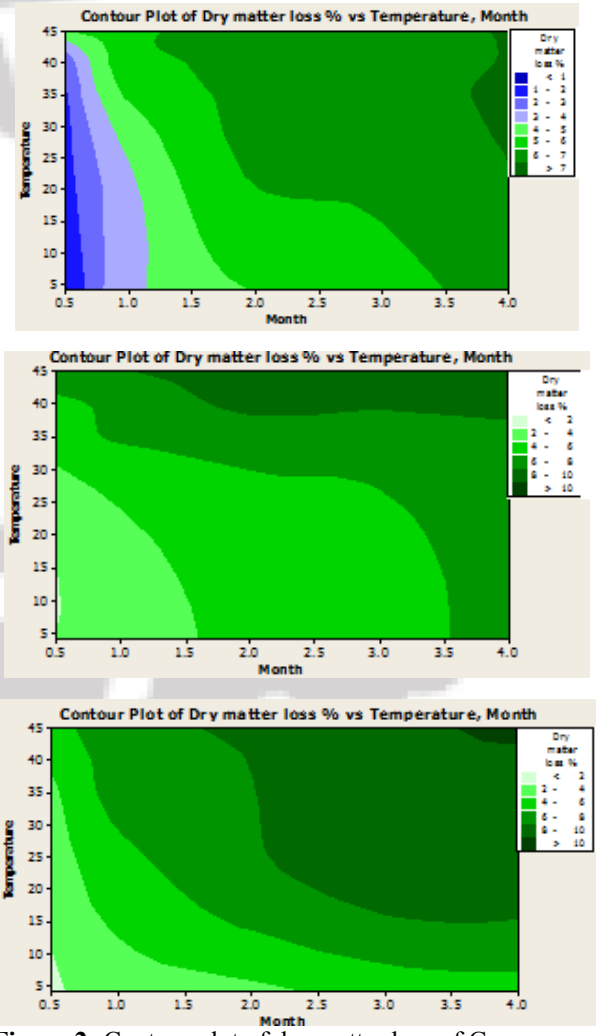

Figure 2: Contour plot of dry matter loss of Green gram, Corn and Cowpea as against period of storage and stored temperature

The contour plots, drawn for Green gram Corn and Cowpea in fig. 2 also depict that there is a positive co relationship between dry mass loss of these grains as against period of storage and stored temperature. When temperature of the stored environment increases, dry mass loss is also concurrently increased. Since increment of ambient air temperature due to climate change is one of major phenomenon, counter plot can easily be used to forecast dry mass loss of these grains due to increment of ambient air temperature.

3.3 Establishment of relationship between dry mass loss of Green gram, Corn and Cowpea as against period of storage, types of packing material and stored temperature

The data obtained from the study were subjected to regression analysis and results revealed that there is a strong positive co-relationship between dry mass loss and 3 variables (Stored temperature, type of packing material and period of storage) of Green gram, Corn and Cowpea because, coefficient of co-relation of these commodities are 0.72, 0.84 and 086 respectively. To quantify this relationship a formula was developed for each grain based on the method described in the regression analysis and they are given below.

Dry Matter Loss (Green gram) = 0.443 + 0.0410 T + 1.15 D + 0.809 P
Dry Matter Loss (Corn) = - 0.027 + 0.0965 T + 0.896 D + 1.09 P
Dry Matter Loss (Cowpea) = - 1.59 + 0.111 T + 1.43 D + 1.32 P
P = packing material 1 for gunny and 2 for poly sack, T = storage temp, D = period of storage (Month)

4. Conclusion

If paddy, green gram corn and cowpea are stored at high temperature, dry mass loss is faster due to rapid rate of respiration. When grains are stored at low temperatures, preferably less than 30°C, the rate of dry mass loss is less. If stored temperature is higher than 35°C, dry mass loss of paddy, green gram, corn and cowpea is rapid.

The developed statistical formulas for the Paddy, Green gram, Corn and Cowpea can be used to quantify the dry mass loss as against period of storage, stored temperature and type of packing material.

Dry Matter Loss (Paddy) = 2.49 + 0.0576 T + 0.435D - 1.06 P
Dry Matter Loss (Green gram) = 0.443 + 0.0410 T + 1.15 D + 0.809 P
Dry Matter Loss (Corn) = - 0.027 + 0.0965 T + 0.896 D + 1.09 P
Dry Matter Loss (Cowpea) = - 1.59 + 0.111 T + 1.43 D + 1.32 P
P = packing material 1 for gunny and 2 for poly sack, T = storage temp, D = period of storage (Month)

The develop contour plots can easily be used to determine the dry mass loss of Paddy, Green gram, Corn and Cowpea as against stored temperature and period of storage. Moreover, these contour plots can be used to predict dry mass loss of Paddy, Green gram, Corn and Cowpea due to increment of ambient air temperature as a result of global warming.

Paddy stored in low temperatures in gunny bags is more desirable than they are stored in poly sack. Green gram, corn and cowpea stored in poly sack are more preferable than they are stored in gunny bags.

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