

Effects of phosphine and extracted plant powder on seed quality and storage pests control

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Abstract

Storage pests are one of the main causes of seed deterioration. Thus, the aim of this research was to study the efficacy of phosphine fumigant in combination with extracted plant powder to protect rice seed from storage pests. The experiment was conducted at Ayutthaya Rice Research Center at 3 periods. The 1st period was during February to June, 2012. Sampling was done with four replications to obtain the number and type of storage pests. The results showed that four storage pests, lesser grain borer (*Rhyzopertha dominica*) angoumois grain moth (*Sitotroga cerealella*) red flour beetle (*Tribolium castaneum*) and rice weevil (*Sitophilus oryzae*) were found with average numbers of 66.85, 4.43, 1.18 and 0.55 insects/250 grams seed respectively. The 2nd period was conducted during August, 2012 to February, 2013, on Suphan Buri 1 variety. A split plot in RCBD with three replications was employed. Main plots were seed fumigated with phosphine and no-phosphine. Sub plots were extracted plant powder, clove (*Syzygium aromaticum* (L.) Merr. & Perry) myrtle grass (*Acorus calamus*) white derris (*Derris malaccensis*) and without extracted plant powder. The results showed that the rice seed with myrtle grass powder could reduce the number of lesser grain borers and grain moths than other extracted plant powder while the rice seed with white derris could reduce the number of red flour beetles. The 3rd period was during March to September, 2013. A split plot in RCBD with four replications was employed to confirm the 2nd period results. In the 3rd period, clove powder was replaced by aloe (*Aloe vera* (L.) Burm.f.) powder because clove reduced seed germination rate. As found in the 2nd period, the rice seed with myrtle grass powder reduced the number of lesser grain borers and grain moths more than the others while the rice seed with white derris reduced the number of red flour beetles. However, there was no relationship between phosphine fumigant and extracted plant powder.

Keyword: phosphine fumigant, extracted plant powder, storage pests

1. Introduction

Storage pests cause damage to both the quantity and quality of stored rice seed (Hayashi et al., 2004) therefore, currently, phosphine is widely used in storage to solve these problems. However, there are some storage pests that are becoming resistant to phosphine. Alternative controls which are safe to use are needed. Many natural substances can be used to control some insects. Insang et al. (2007) found that crude extracts from clove, myrtle grass, white derris and seed of sugar apple could effectively kill the house dust mite. Omotoso and Oso (2005) found that aloe had toxic effects on the red flour beetle. Myrtle grass and derris were also suggested to Thai famers as pesticides (Department of Agriculture, 2009). The purpose of this research was study efficacy of phosphine fumigant in combination with extracted plant powders.

2. Material and Methods

2.1. First period: Surveying of type and number of storage pests

Storage pests were randomly sampled from paddy packaged in sacks stored at the Ayutthaya Rice Research Center during February to June 2012. Samples of 250 grams seed weight of four replications were collected every 2 weeks for a period of five months to determine the type and number of important storage pests.

2.2. Second period: Effect of phosphine and extracted plant powder to control storage pests

A split plot in RCBD with three replications was employed in rice seed, each treatment was 250 grams of Suphan Buri 1 variety packed into a plastic box 13.5 x 13.5 x 5 cm³. Main plots were seed fumigated with phosphine and no phosphine. Sub plots were 5 grams of four extracted plant powder: clove (*Syzygium aromaticum* (L.) Merr. & Perry) myrtle grass (*Acorus calamus*) white derris (*Derris malaccensis*) and without plant powder, completely mixed with rice seed. Then these placed in storage of Ayutthaya Rice Research Center for 6 months from August 2012 to February 2013. During the period, each treatment had been determined one time per month to monitor the data of type and number of grain moths, lesser grain borers and red flour beetle, seed germination rate and the percentage of weight loss.

2.3. Third period: Confirm second period results

The experiment was conducted as same as the former to confirm the previous result. However, there were some changes in this experiment for study on farmer's storage condition; each treatment volume increased from 250 grams to 10 kilograms which was packed in sacks. Aloe (*Aloe vera* (Linn.) Burm.f.) powder was used instead of clove powder. Each treatment had been determined by 1 kilogram one time per month. The percentage of dry weight loss was determined by using a formula described by Adams (1976). This experiment was conducted during March - September 2013.

$$\% \text{ Weight loss} = \frac{(UNd) - (DNu) \times 100}{U(Nd + Nu)}$$

Where

U = weight of undamaged
Nu = number of undamaged
D = weight of damaged
Nd = number of damaged

3. Results and Discussions

3.1. First period: surveying of type and number of storage pests

At the first period, it can be seen that the number of lesser grain borers was the largest at 66.85 insects/250 grams seed while the others, Angoumois grain moth, red flour beetle and rice weevil were at 4.43, 1.18 and 0.55 insects/250 grams seed, respectively. However, due to an enormous flooding in this area in September 2011 therefore only some important storage pests were found (Fig. 1)

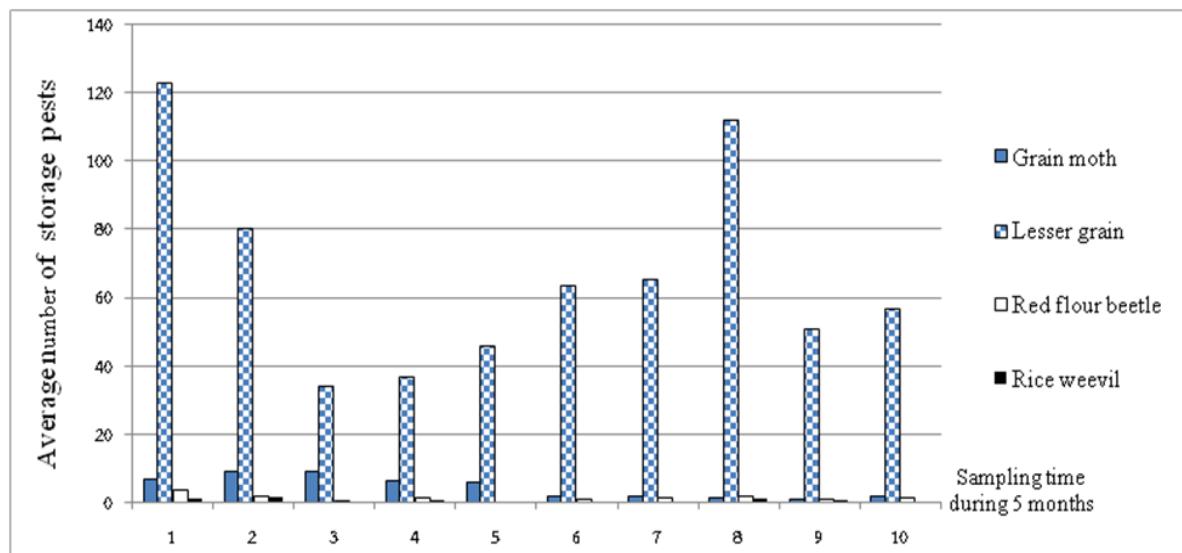


Figure 1 The average number of storage pests found in Ayutthaya Rice Research Center during February - June 2012.

3.2. Second period: effect of phosphine and extracted plant powder to control storage pests

3.2.1. Effect of phosphine fumigant

We found that phosphine could reduce the number of Angoumois grain moths at the first month after storage but at 6 months after storage, there was no difference between treating with phosphine and no-phosphine (53.83 and 43.83 insects/250 grams seed respectively, (Table 1). However, treated phosphine and no-phosphine method were similar for protecting stored rice seed from lesser grain borer and red flour beetle (Table 2, 3).

3.2.2. Effect of plant powder

Clove could protect stored rice seed from grain moth early in this experimental period. Pumnuan and Insang (2012) reported that clove contains a chemical called *eugenol* which is highly toxic to stored product mites. By the way, there was a low number of grain moths in seed mixed with myrtle grass compared to other plant powder methods, 25 insects/250 grams seed at 6 months after storage (Table 1).

3.2.3. Lesser grain borer (*Rhyzopertha dominica*)

The study found that seeds mixed with clove and myrtle grass can continually prevent the infestation of lesser grain borer better than other plant powder methods (Table2). The Department of Agricultural Extension (2008) stated that there is an essential oil called *acalamol aldehyde* in myrtle grass root, which is toxic to the nervous system of insects by acting as an insecticide effecting on lesser grain borer etc.

3.2.4. Red flour beetle (*Tribolium castaneum*)

White derris tend to protect stored rice seed from red flour beetle though the period compared to clove myrtle grass and control treatment (Table 3).

Table 1 The average number of Angoumois grain moths in rice seed samples during storage (August 2012 – February 2013) at Ayutthaya Rice Research Center.

Treatments		Storage duration (month) ^{1/}					
		1	2	3	4	5	6
Plant powders	Clove	22.33 a	67.83 b	156.83 a	186.33 a	81.83 a	90.83 a
	Myrtle grass	75.33 a	88.67 b	80.50 a	38.83 b	17.17 b	25.00 b
	White derris	97.33 a	150.50 a	153.83 a	85.33 ab	42.67 b	41.33 ab
	Control	100.00 a	77.17 b	94.50 a	121.50 ab	36.33 b	38.17 ab
Phosphine		46.58 b	99.50 a	93.42 b	69.75 b	45.33 a	53.83 a
No Phosphine		100.92 a	92.58 a	149.42 a	146.25 a	43.67 a	43.83 a

^{1/}Mean in each column by the same letter is not significantly different at level 95 %**Table 2** The average number of lesser grain borers in rice seed samples during storage (August 2012 – February 2013) at Ayutthaya Rice Research Center.

Treatments		Storage duration (month) ^{1/}					
		1	2	3	4	5	6
Plant powders	Clove	0.33 a	4.17 b	10.83 b	47.67 b	22.17 c	18.17 b
	Myrtle grass	0.83 a	4.17 b	12.33 b	22.50 b	6.50 c	9.33 b
	White derris	1.33 a	31.50 a	175.67 a	217.50 a	96.83 a	60.17 a
	Control	0.67 a	12.67 b	53.50 b	232.33 a	42.50 b	50.50 a
Phosphine		0.83 a	13.92 a	68.42 a	93.08 b	39.42 a	37.25 a
No phosphine		0.75 a	12.33 a	57.75 a	166.92 a	44.58 a	31.83 a

^{1/}Mean in each column by the same letter is not significantly different at level 95 %**Table 3** The average number of red flour beetles in rice seed samples during storage (August 2012 – February 2013) at Ayutthaya Rice Research Center.

Treatments		Storage duration (month) ^{1/}					
		1	2	3	4	5	6
Plant powders	Clove	2.83 a	10.33 a	71.50 a	148.67 a	53.50 a	159.83 a
	Myrtle grass	3.67 a	8.50 a	65.33 a	47.83 ab	42.50 ab	78.17 a
	White derris	2.00 a	2.50 b	23.67 a	10.83 b	2.17 c	23.33 a
	Control	2.83 a	11.17 a	3.50 a	29.17 b	19.50 bc	72.50 a
Phosphine		2.92 a	7.25 a	31.50 a	23.42 a	27.67 a	102.08 a
No phosphine		2.75 a	9.00 a	50.50 a	94.83 a	31.17 a	64.83 a

^{1/}Mean in each column by the same letter is not significantly different at level 95 %

3.2.5. Second period: seed germination rate and percentage of weight loss

The study found that after 6 months in storage, seed germination rate of treatments mixed with myrtle grass white derris and no-plant powder were similarly decreased while clove causing seed germination rate rapidly dropped (Fig.2) since it contains 14-23% oil (Homhual, 2014) . There was found that percentage of weight loss of rice seed of all treatments increased all over the period. However, this was low when treated rice seed by phosphine with clove and myrtle grass (Fig. 3) but at 6 months after storage there was not found the difference among all treatments.

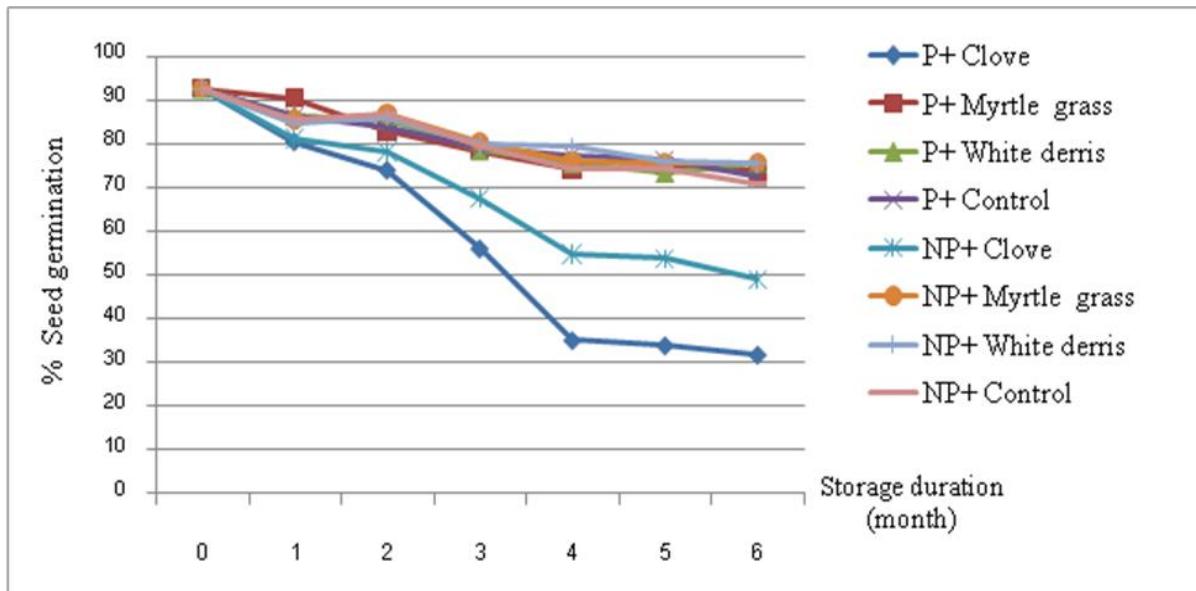


Figure 2 Percentage of seed germination in each treatment during August 2012 – February 2013.

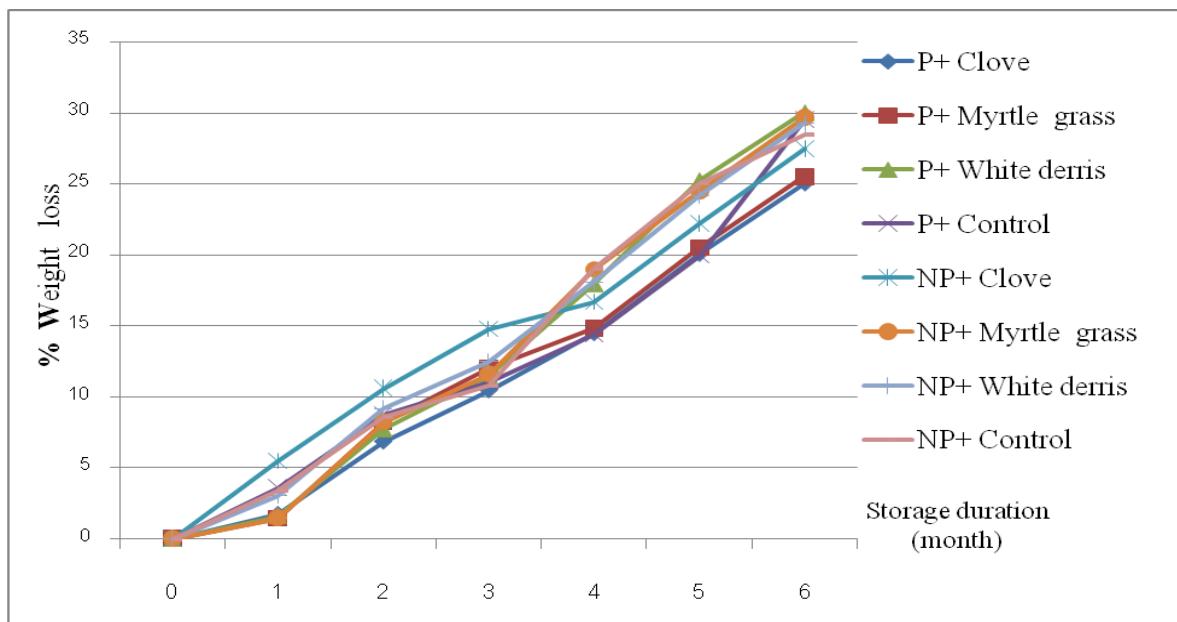


Figure 3 Percentage of weight loss in each treatment during August 2012 – February 2013.

3.3. Third period: confirm second period results

The experiment was conducted to confirm the results of 2nd period. Myrtle grass and white derris powder which are efficiency to prevent stored pests were selected for studying in this period. Moreover, even clove could protect stored rice seed from lesser grain borer and grain moth at the early of 2nd period, by the way, in the 3rd period, it was replaced by aloe which could control storage moth and weevil (Kenya Agricultural Research Institute, 2005)

3.3.1. Effect of phosphine fumigant

The result shown that phosphine had reduced the number of lesser grain borers and red flour beetles with 0.42 and 0.08 insects/1 kilogram seed consequently, for 1 month after storage. However, after that there was no statistical difference, the number of grain moths of stored rice seed treated with phosphine and no-phosphine were similar all over the 3rd period.

3.3.2. Effect of plant powder, Angoumois grain moth (*Sitotroga cerealella*)

Consistent with the 2nd period result, this study found that when using myrtle grass powder mixed with rice seed could prevent the infestation of grain moth (Table 4) with an average of 6.75 insects/1 kilogram seed found at 6 months after storage while these of white derris, aloe and no-plant powder treatments were 32.25, 24.38 and 26.63 insects/1 kilogram seed respectively. However, over 5 months after storage, there was low number of grain moths found in rice seed mixed with aloe powder treatment.

Table 4 The average number of grain moths in rice seed samples during storage March - September 2013) at Ayutthaya Rice Research Center.

Treatments	Storage duration (month) ^{1/}					
	1	2	3	4	5	6
Plant powders	Myrtle grass	0.00 a	0.00 a	0.10 b	1.25 b	4.13 a
	White derris	0.00 a	0.17 a	0.80 ab	2.13 ab	12.63 a
	Aloe	0.00 a	0.00 a	1.30 a	1.13 b	3.75 a
	Control	0.00 a	0.83 a	0.30 ab	4.13 a	11.50 a
Phosphine		0.00 a	0.13 a	0.55 a	2.31 a	7.63 a
None phosphine		0.00 a	0.38 a	0.70 a	2.00 a	8.38 a

^{1/}Mean in each column by the same letter is not significantly different at level 95 %

3.3.3. Lesser grain borer (*Rhyzopertha dominica*)

The study found that the number of lesser grain borers of stored rice seed mixed with myrtle grass was lower than other plant powder methods, that consistent with the 2nd period result (Table 5).

3.3.4. Red flour beetle (*Tribolium castaneum*)

In the 3rd period, there found few number of red flour beetles that could not make the conclusion of the experiment (Table 6).

Table 5 The average number of lesser grains in rice seed samples during storage March - September 2013) at Ayutthaya Rice Research Center.

Treatments		Storage duration (month) ^{1/}					
		1	2	3	4	5	6
Plant powders	Myrtle grass	11.67 a	44.38 a	40.88 a	45.63 b	82.50 a	89.00 a
	White derris	10.50 a	47.00 a	76.50 a	73.63 ab	106.88 a	128.75 a
	Aloe	9.67 a	48.63 a	79.00 a	50.00 b	85.50 a	134.75 a
	Control	19.17 a	66.00 a	74.25 a	85.25 a	101.88 a	162.25 a
Phosphine		0.42 b	42.88 a	59.56 a	63.50 a	88.56 a	126.75 a
None phosphine		25.08 a	60.13 a	75.75 a	63.75 a	99.81 a	130.63 a

^{1/}Mean in each column by the same letter is not significantly different at level 95 %**Table 6** The average number of red flour beetles in rice seed samples during storage March - September 2013) at Ayutthaya Rice Research Center

Treatments		Storage duration (month) ^{1/}					
		1	2	3	4	5	6
Plant powders	Myrtle grass	0.00 a	2.75 a	4.25 a	2.88 a	3.13 a	4.25 a
	White derris	0.17 a	1.63 a	2.13 a	2.50 a	2.50 ab	3.63 a
	Aloe	0.17 a	1.50 a	3.75 a	2.50 a	1.75 b	4.38 a
	Control	0.33 a	2.38 a	4.38 a	2.75 a	1.75 b	4.75 a
Phosphine		0.08 b	2.38 a	3.06 a	2.88 a	1.94 a	4.06 a
None phosphine		0.25 a	1.75 a	4.19 a	2.44 a	2.63 a	4.44 a

^{1/}Mean in each column by the same letter is not significantly different at level 95 %

3.4. Third period: seed germination rate and percentage of weight loss

Seed germination rate and percentage of weight loss by count and weight method. According to the results of the 2nd period, the germination rate of all treatments continually dropped through 6 months after storage. By the way, there was not found the statistical difference among all treatments in each month. However, this of stored rice seed mixed with white derris was the lowest at 73.94 % at the end of this period (Fig. 4). Percentage of weight loss was lowest when rice seed treated with phosphine and myrtle grass that was consistent with lower number of grain moths and lesser grain borers found in this treatment (Fig. 5). Moreover, at 6 months after storage, there was the statistical difference of weight loss between rice seed treated with phosphine and myrtle grass compared to control treatment.

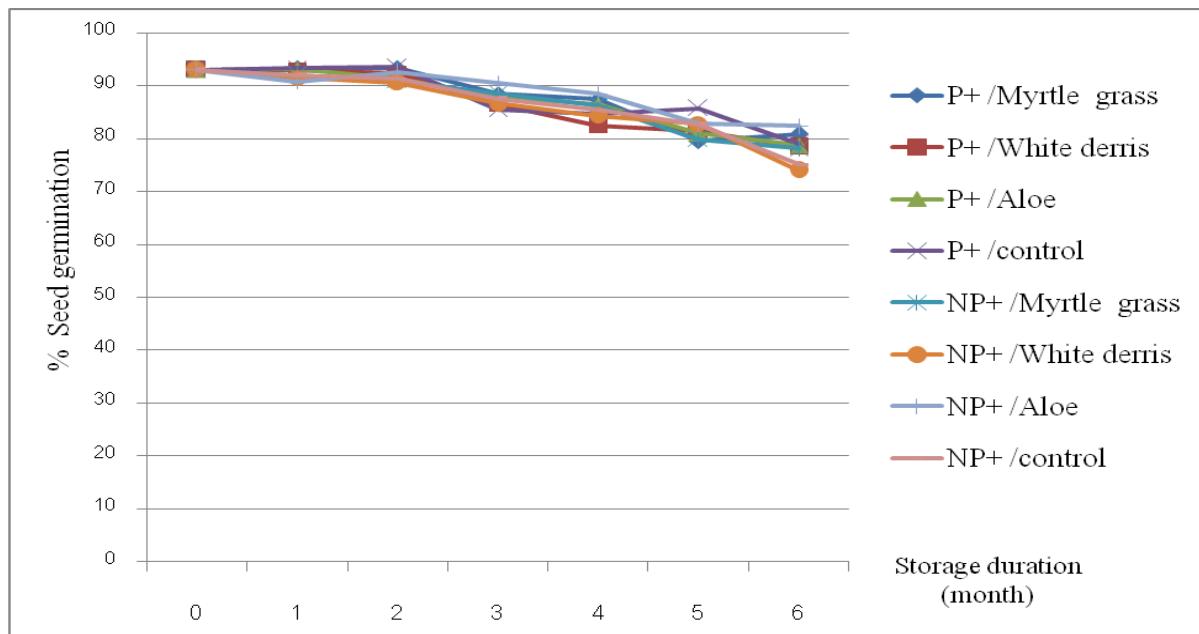


Figure 4 Percentage of seed germination in each treatment during March - September 2013.

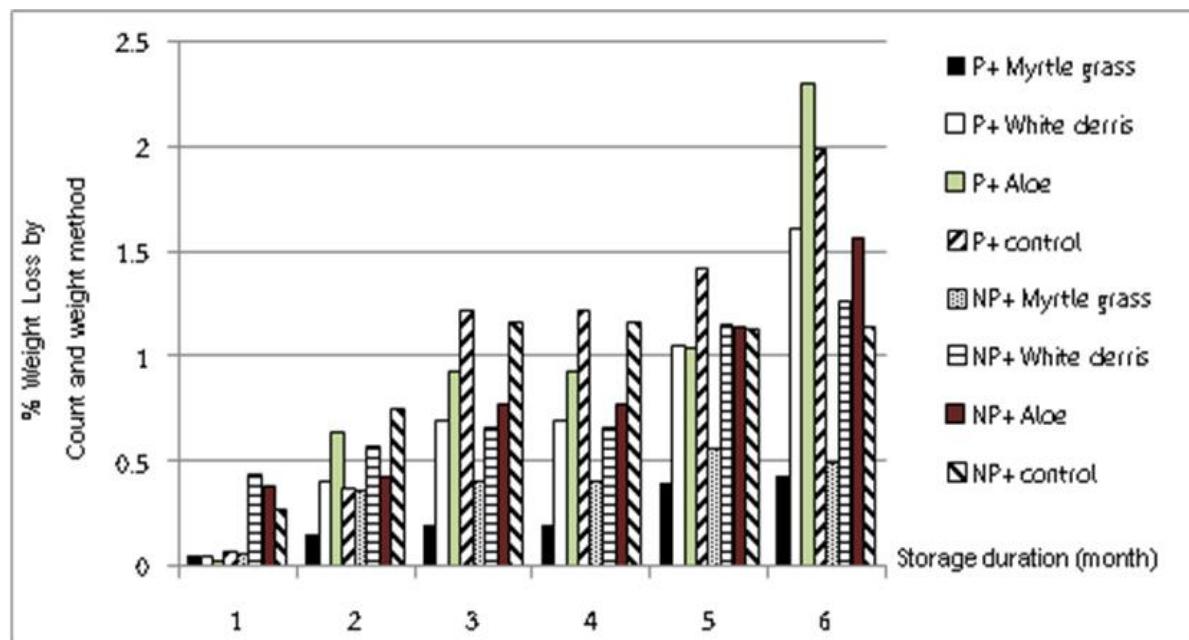


Figure 5 Percentage of weight loss by Count and weight method in each treatment during March - September 2013.

4. Conclusions

Phosphine fumigant had protected stored rice seed from lesser grain borer, angoumois grain moth and red flour beetle for short time after that these of phosphine and no-phosphine treatments were similar. The myrtle grass could reduce the number of lesser grain borers and grain moths in stored rice seed while white derris tent to reduce red flour beetle. Furthermore, clove which contains oil dramatically reduced seed germination rate while phosphine fumigant and other types of extracted plant powder, myrtle grass white derris and aloe did not effect on it. However, percentage of weight loss of combining phosphine and myrtle grass

powder using in rice seed was low that is consistent with the number of lesser grain borers and grain moths found.

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