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Effect of Storage Methods and Fumigation with Phosphine on Storage Efficacy, Germination and Seedlings Parameters of Wheat During Storage Periods

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ABSTRACT

A laboratory experiment was carried out at Seed Technology Research Unit at Mansoura, Dakahlia Governorate, Field Crops Research Institute, Agricultural Research Center, Egypt, to evaluate the effect of storage methods (normal storage in cotton bags and sealing storage in plastic jars and metal packages) and fumigation with phosphine at 0, 3, 5 and 7 tablets/m^3 on storage efficacy, germination and seedlings parameters of wheat during different storage periods (3, 6 and 9 months after harvesting). The most important results can be summarized as follows:- Increasing storage periods of wheat seed from 3 to 6 and 9 months significantly affected storage efficacy characters (insect infestation and weight loss percentages), final germination percentage and seedling parameters (seedling length, root length, shoot length and seedlings fresh and dry weights). - The best results of storage efficacy of wheat recorded when sealed stored in metal packages, followed sealed stored in plastic jars and lastly in cotton bags. Whereas, highest germination and seedling parameters were recorded when sealed stored in metal packages, followed by normal stored in cotton bags and lastly stored in plastic jars. - The lowest percentages of insect infestation and weight loss in wheat seeds were obtained from fumigation with phosphine at the rate of 7 tablets/m^3. While, maximum values of germination and seedling parameters were obtained from fumigation with phosphine at the rate of 5 tablets/m^3. This study recommended that fumigation wheat seeds before storage in metal packages with phosphine at the rate of 5 tablets/m^3 under the environmental conditions of the experiment in Mansoura, Dakahlia Governorate, Egypt.

Keywords: Wheat, storage periods, storage methods, fumigation, phosphine, storage efficacy, germination and seedlings parameters.

INTRODUCTION

Wheat (*Triticum aestivum vulgare* L.) is considered as a strategic cereal crop and the main food for the human. It is the stable food crop in the urban and rural areas. Wheat is used widely in blending with maize or barley flour to make bread, macaroni, biscuit and sweets. It is also worth mentioning that wheat straw is a main source of dry fodder for animals. In Egypt, the total cultivated area of wheat reached about 3.392 million feddan and the total production exceeded 9.280 million tons with an average of 18.23 ardab/fed (FAO, 2016).

In order to prevent the quantitative and qualitative losses due to several biotic and abiotic factors during storage, several methods are being adopted such as seed treatment with suitable chemicals or plant products and storing in safe containers, besides sanitation of the storage place.

Storage period have a huge influence on the quality of wheat seeds. Where, the goal of storing is to provide optimum preservation of physiological and physical characteristics of seed (Đukanović and Sabovljević, 2001). In this regard, Roberts (1972) reported that seed deterioration during storage was due to the damage in membrane, enzyme, proteins and nucleic acid, in addition accumulation with time such degenerative changes result in complete disorganization of membranes and cell organells and ultimately causing death of the seed and loss of germination. Singh *et al.* (2000) observed 5-17% reduction in seed germination when wheat seeds were stored approximately for five months. Magan *et al.* (2003) reported that the post harvest loss of wheat grain has been found to be highest during storage, particularly the insects were serious threat to wheat grain. Attia *et al.* (2014) concluded that increasing storage periods of wheat grains from 3 to 6 months significantly increased number of infected wheat grains, damage grains percentage, grains weight loss percentage over all studied grain treatments. Attia *et al.* (2015) revealed that storage efficacy of paddy rice (number of insects, insect infestation percentage and grains weight loss percentage) was significantly increased due to increasing storage periods from 2 to 4 and 6 months from beginning of storage.

The seeds are stored from harvest to sowing. The extent of storability influenced by storage methods. In general seed stored in moisture impervious sealed containers provide suitable environment for storage, offer protection against contamination and also acts as a barrier against the escape of seed treatment chemicals than in moisture pervious containers. In this respect, Singh *et al.* (2000) observed that when wheat seeds stored in concrete bins, the seed germination was higher against metal bins. Sinha and Sharma (2004) noticed that the maximum changes in wheat seed quality were reported when stored in jute bags compared to metal bins. Raza *et al.* (2010) showed that moisture content was increased during storage when stored wheat grains in cotton bags and earthen pots resulting in higher test weights and flour yield. Tin containers performed better in retaining low fat acidity values. Chattha *et al.* (2012) concluded that wheat seed stored in gunny, cloth and plastic bags were in good terms with temperature, moisture content and germination capacity in comparison with those in metal and earthen bins. Seadh *et al.* (2015) found that the best results of physical characters of milled rice resulted from samples of milled rice grains stored in gunny packages, followed stored in normal packages (twisting plastic), and then stored in light cloth packages.

Fumigation is a technique employed to eliminate insect pests in stored seeds by using gas. Fumigation with phosphine (PH_3, hydrogen phosphide) has the

potential to disinfest seed stored in silo bags. Phosphine fumigation offers a cost-effective method of treating seed so that insects are controlled. In this regard, Matthews *et al*. (1970) studied the effects of fumigation of wheat grains with phosphine on composition and quality of grains. They showed that phosphine residue content increased somewhat near the end of the storage period (6 months). Winks (1984) concluded that the recommended strategy for phosphine fumigations is to maintain a lethal concentration until the most resistant stages mature into less resistant forms. Lorini *et al*. (2002) stated that the gas distribution should be uniform in all parts of the mass of grains or seeds to be treated, thus controlling all pests in their different life stages. The release rate of the phosphine gas (PH_3) coming from the fumigation pellets will determine the time required for total mortality of the pests and efficiency of the process. Collins *et al*. (2005) reported that phosphine is relatively easy to use, versatile, cheap, and accepted internationally as a low-residue treatment. Although a number of alternative fumigants are being developed for stored grain, for example, carbonyl sulphide, hydrogen cyanide and ethyl formate none of these can match the combined properties of phosphine. Badawi *et al*. (2014) suggested that seeds of wheat can be stored in the open air, while maintaining the seed of good quality in the moisture content does not exceed 14% after fumigation with phosphine in relative humidity up to 57%. Attia *et al*. (2015) showed that the best results of storage efficacy (number of insects, insect infestation percentage and grains weight loss percentage) of paddy rice obtained when treating with phosphine at the rate of 6 balls/ton, followed treating with phosphine at the rate of 4 balls/ton, then phosphine at the rate of 2 balls/ton. Seadh *et al*. (2015) pointed out that the best results of physical characters of milled rice obtained when treating with phosphine at the rate of 6 balls/ton, followed treating with phosphine at the rate of 4 balls/ton, then treating with phosphine at the rate of 2 balls/ton.

Therefore, this investigation was established to study the effect of storage methods, fumigation with phosphine and their interaction on storage efficacy, germination and seedlings parameters of wheat during different storage periods (3, 6 and 9 months after harvesting) under the environmental conditions of Dakahlia Governorate, Egypt.

MATERIALS AND METHODS

Under the laboratory conditions of the Seed Technology Research Unit at Mansoura, Dakahlia Governorate, Field Crops Research Institute, Agricultural Research Center, Egypt, a laboratory experiment was carried to evaluate the effect of storage methods, fumigation with phosphine and their interaction on storage efficacy, germination and seedlings parameters of wheat during different storage periods (3, 6 and 9 months after harvesting).

The experiment was arranged in factorial experiment in randomized complete block design (RCBD) with four replications.

The first factor contained different storage periods of wheat after harvesting time (3, 6 and 9 months).

The second factor included storage methods of seeds for wheat as follows; normal storage (stored seeds in cotton bags) and sealing storage (stored seeds in plastic jars and metal packages).

The third factor have seed treatments of wheat (fumigation with phosphine) before beginning of storage as follows:

1. Control treatment (untreated seeds).
2. Treating seeds with phosphine at the rate of 3 tablets/m^3.
3. Treating seeds with phosphine at the rate of 5 tablets/m^3.
4. Treating seeds with phosphine at the rate of 7 tablets/m^3.

About, 250 g of wheat grains with 12-13% moisture content in each replicate were stored in various packages as formerly mentioned and then treated with various rates of phosphine for three days and then start of storage.

The studied wheat Sids 12 cultivar was obtained directly after harvesting from the Agricultural Research Station Farm in Tag AL-Ezz, Dakahlia Governorate, Agricultural Research Center, Egypt.

The phosphine (aluminium phosphide) was produced by T. Stanes & Company Limited, India and obtained from Gaara Establishment for Import and Export Co.

Phosphine or hydrogen phosphide (PH_3) is very toxic to all forms of animal life, hence exposure of human beings even to small amounts should be avoided. It is important to mention that the activity of phosphine tablets will take action when it is subject to air. Poisoning can result from ingestion or inhalation; however, the gas is not absorbed through the skin. A concentration of 2.8 mg/L (2000 ppm in air) is lethal to humans in a very short time. The threshold limit value is usually set at 0.3 ppm for a 40 hour work week.

STUDIED CHARACTERS:

A- Storage efficacy characters:

1- Insect infestation percentage. After each storage period (3, 6 and 9 months from harvesting), four replicates 100 seeds from each treatment were manually picked from each package from different depth randomly for inspection. Seeds which having holes or infestation were collected also, the seed which showed signs of insect damage were considered as infested. The infestation level was expressed as number and percentage damage seeds according to formula of Jood *et al*. (1996).

$$\text{Damage grains percent} = \frac{\text{Number of insect damage}}{\text{Number of total seeds inspected}} \times 100$$

2- Weight loss percentage. After 3, 6 and 9 months, the dry mass (weight) losses caused by insect infestation were calculated as follows according to Dick (1987).

$$\text{Dry mass (weight) loss \%} = \frac{(U\,Nd) - (D\,Nu)}{U\,(Nd + Nu)} \times 100$$

Where: Nu = Number of undamaged grains.
Nd = Number of damaged grains.
U = Weight of undamaged grains.
D = Weight of damage grains.

B- Standard germination test:

Random sample of 100 seeds for each treatment were allowed to germinate under the environmental conditions of Seed Technology Research Unit at Mansoura, Dakahlia Governorate, Field Crops Research Institute, Agricultural Research Center, Egypt at the end of each storage period as the rules of International Seed Testing Association (ISTA, 1996) on top filter paper in sterilized Petri-dishes (14 cm diameter) and each Petri-dish contains 25 seeds.

The germinated seeds were counted and first count defined as the number of germinated seeds at the fourth day of wheat. Then, every 24 hours the number of germinated seeds were counted until end of germination test (8 days) to recorded:

- Final germination percentage (FG %). Normal seedlings of each replicate were counted at the end of standard germination test and expressed as percentage according to the following equation described by ISTA (1996):

$$FG\ \% = \frac{\text{Number of normal seedlings}}{\text{Number of total seeds}} \times 100$$

C- Seedling parameters:

1- Seedling length (cm). 2- Root length (cm).
3- Shoot length. 4- Seedlings fresh weight.
5- Seedlings dry weight: The weight of ten seedling at random per replicate were recorded and expressed in gram (g) after oven drying at 70 º C until constant weight (Agrawal, 1986).

Data were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) for the factorial experiment in completely randomized design (CRD) as published by Gomez and Gomez (1984) by using "MSTAT-C " computer software package. Least significant of difference (LSD) method was used to test the differences between treatment means at 5 % level of probability as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1- Effect of storage periods:

Increasing storage periods of wheat seeds from 3 to 6 and 9 months significantly affected storage efficacy characters (insect infestation and weight loss percentages), germination parameter (final germination percentage) and seedling parameters (seedling length, root length, shoot length and seedlings fresh and dry weights) of wheat as shown from data in Tables 1and 2.

From obtained results in Tables 1and 2, it could be noticed that the insects did not found in stored wheat seeds after 3 months from beginning of storage, therefore wheat seeds did not infested with insect and did not lost any weight after 3 months from beginning of storage. However, insect infestation and weight loss percentages of both wheat seeds were significantly increased due to increasing storage periods from 6 to 9 months from beginning of storage. Where, the highest percentages insect infestation percentage and weight loss percentage of wheat seeds were resulted from storage wheat seeds up to 9 months, and followed by storage wheat seeds up to 6 months. These results may be owing to unsuitable conditions for storage or instability of the temperature and humidity during storage periods, moreover faded the effect of fumigation wheat seeds with phosphine before storage (Attia *et al.*, 2014 and 2015).

Table 1: Insect infestation, weight loss and final germination percentages and seedling length of wheat as affected by storage periods, storage methods and fumigation with phosphine.

Characters / Treatments	Insect infestation (%)	Weight loss (%)	Final germination (%)	Seedling length (cm)
A- Storage periods:				
3 Months	0.00	0.00	90.1	22.83
6 Months	3.83	17.28	87.0	21.75
9 Months	8.51	20.39	85.6	18.44
F. test	*	*	*	*
LSD at 5 %	0.26	0.15	1.0	0.21
B- Storage methods:				
Cotton bags	4.56	14.18	87.1	21.04
Plastic jars	4.21	13.99	86.7	21.01
Metal packages	3.57	9.50	88.9	20.97
F. test	*	*	*	NS
LSD at 5 %	0.25	0.14	0.9	-
C- Fumigation with phosphine:				
Untreated (control)	4.21	12.82	85.7	20.73
3 Tablet phosphine/m^3	4.19	12.57	87.2	20.84
5 Tablet phosphine/m^3	4.14	12.62	89.0	21.31
7 Tablet phosphine/m^3	3.91	12.21	88.2	21.15
F. test	*	*	*	*
LSD at 5 %	0.16	0.13	1.1	0.24
D- Interactions:				
A × B	*	*	*	*
A × C	*	*	NS	*
B × C	*	*	*	*
A × B × C	*	*	*	*

Concerning final germination percentage and seedling parameters (seedling length, root length, shoot length, seedlings fresh and dry weights) of wheat, it were significantly decreased due to increasing storage periods from 3 to 6 and 9 months from beginning of storage. Where, the highest percentage of final germination and the highest values of seedling, root and shoot lengths and seedlings fresh and dry weights of wheat seeds were resulted from storage wheat seeds up to 3 months, followed by storage wheat seeds up to 6 months and lastly storage wheat seeds up to 9 months. The seed deterioration during storage was due to the damage in membrane, enzyme, proteins and nucleic acid, in addition accumulation with time such degenerative changes result in complete disorganization of membranes and cell organells and ultimately causing death of the seed and loss of germination (Roberts, 1972). These results are in agreement with those reported by Singh *et al*. (2000).

Table 2: Root and shoot lengths, seedlings fresh and dry weights of wheat as affected by storage periods, storage methods and fumigation with phosphine.

Characters Treatments	Root length (cm)	Shoot length (cm)	Seedlings fresh weight (g)	Seedlings dry weight (g)
A- Storage periods:				
3 Months	15.45	9.63	3.024	0.908
6 Months	14.82	9.55	2.939	0.524
9 Months	14.55	8.30	2.211	0.393
F. test	*	*	*	*
LSD at 5 %	0.03	0.05	0.070	0.009
B- Storage methods:				
Cotton bags	14.91	9.18	2.676	0.580
Plastic jars	14.84	8.93	2.669	0.576
Metal packages	15.06	9.37	2.830	0.669
F. test	*	*	*	*
LSD at 5 %	0.02	0.04	0.069	0.008
C- Fumigation with phosphine:				
Untreated (control)	14.80	8.94	2.226	0.580
3 Tablet phosphine/m^3	14.87	9.10	2.657	0.601
5 Tablet phosphine/m^3	15.09	9.37	3.030	0.632
7 Tablet phosphine/m^3	14.99	9.23	2.986	0.620
F. test	*	*	*	*
LSD at 5 %	0.03	0.06	0.081	0.010
D- Interactions:				
A × B	*	*	*	*
A × C	NS	NS	*	NS
B × C	*	NS	*	NS
A × B × C	*	NS	*	*

2- Effect of storage methods:

Studied storage methods of wheat seeds *i.e.* normal storage (stored wheat seeds in cotton bags) and sealing storage (stored wheat seeds in plastic jars and in metal packages) significantly affected storage efficacy characters (insect infestation and weight loss percentages), germination parameter (final germination percentage) and seedling parameters (root length, shoot length and seedlings fresh and dry weights) of wheat (Tables 1 and 2).

The lowest insect infestation and weight loss percentages of wheat seeds (3.57 and 9.50 %) were recorded in samples of wheat seeds sealed stored in metal packages, followed sealed stored in plastic jars. Whereas, the highest insect infestation and weight loss percentages in wheat seeds (4.56 and 14.18 %) were produced from samples of wheat seeds normal stored in cotton bags. The reduction in percentage of insect infestation in wheat seeds by sealed stored in metal packages may be ascribed to completely effective in maintaining seed moisture content and prevent the arrival of insects to seeds, which helps to reduce the incidence of insects. Chattah *et al.* (2012) confirmed these results.

The highest final germination percentage and seedling parameters (root length, shoot length, seedlings fresh and dry weights) of wheat were recorded in samples of wheat seeds sealed stored in metal packages, followed that normal stored in cotton bags. While, the lowest final germination percentage and seedling parameters of wheat were produced from the samples of wheat seeds sealed stored in plastic jars. These results are mainly because of maintenance of moisture content during the storage period which resulted in lower respiration rate, lower metabolic activity and maintenance of higher seed vigour during storage. Chattha *et al.* (2012) confirmed these results. However, Singh *et al.* (2000) observed that when wheat seeds stored in concrete bins, the seed germination was higher against metal bins.

3- Effect of fumigation with phosphine:

Statistical analysis of the obtained data exhibited that studied wheat seeds treatment before beginning of storage (fumigation with phosphine at the rates of 3, 5 and 7 Tablet phosphine/m^3) had a significant effect on storage efficacy characters (insect infestation and weight loss percentages), germination parameter (final germination percentage) and seedling parameters (seedling length, root length, shoot length and seedlings fresh and dry weights) of wheat (Tables 1 and 2).

Table 3: Insect infestation percentage in wheat grains as affected by the interaction among storage periods, storage methods and fumigation with phosphine.

Storage periods	Storage methods	Fumigation with phosphine			
		Untreated	3 Tablet /m^3	5 Tablet /m^3	7 Tablet /m^3
3 Months	Cotton bags	0.00	0.00	0.00	0.00
	Plastic jars	0.00	0.00	0.00	0.00
	Metal packages	0.00	0.00	0.00	0.00
6 Months	Cotton bags	5.08	4.71	3.89	4.59
	Plastic jars	4.53	4.31	3.52	3.40
	Metal packages	3.35	3.25	2.78	2.61
9 Months	Cotton bags	9.42	9.28	9.25	8.56
	Plastic jars	9.36	8.65	8.46	8.37
	Metal packages	9.33	8.60	6.46	6.41
	F. test		*		
LSD at 5 %			0.89		

The highest insect infestation and weight loss percentages of wheat seeds (4.21 and 12.82 %) were resulted from wheat seeds stored without fumigation with phosphine (control treatment). Whereas, the lowest insect infestation and weight loss percentages of wheat seeds (3.91 and 12.21 %) were produced from treating wheat seeds with phosphine at the rate of 7 tablets/m^3. The second best treatment was treating wheat seeds with phosphine at the rate of 5 tablets/m^3 and followed by treating wheat seeds with phosphine at the rate of 3 tablets/m^3 without significant differences between them. The favourable role of treating wheat seeds before storage with phosphine at the rate of 7 tablets/m^3 which reduced insect infestation percentage may be ascribed to phosphine gas (PH_3), that formed by react between tablets of aluminum phosphide placed in grain and water in the air, is prevented insects piercing and entering into seeds by poison effect. Moreover, Winks (1984) concluded that phosphine fumigations maintained a lethal concentration until the most resistant stages mature into less resistant forms. In this regard, phosphine was the primary fumigants currently being used commercially for stored products. These findings are in agreement with those reported by Badawi *et al.* (2014) and Attia *et al.* (2015).

The highest final germination percentage and seedling parameters (seedling length, root length, shoot

length, seedlings fresh and dry weights) of wheat were produced from treating wheat seeds with phosphine at the rate of 5 tablets/m^3. However, treating wheat seeds with phosphine at the rate of 7 tablets/m^3 ranked after aforementioned treatment and followed by treating wheat seeds with phosphine at the rate of 3 tablets/m^3. The lowest final germination percentage and seedling parameters of wheat were resulted from wheat seeds stored without fumigation with phosphine (control treatment). The increasing in final germination percentage of wheat seeds by treating seeds with phosphine at the rate of 5 or 7 tablets/m^3 probably due to efficiency of phosphine at these concentrations in reduction damaged seeds and seeds weight loss percentages as result of its poison effect (Winks, 1984 and Collins *et al.*, 2005), prevented the insects piercing and entering into grains, consequently increasing germination parameters.

4- Effect of the interactions:

There are many significant effects of the interactions among studied factors on studied characters. We present only the significant three way interaction among storage periods, storage methods and fumigation with phosphine on studied characters as presented in Tables 1 and 2.

Concerning the third interaction among studied factors *i.e.* storage periods, storage methods and fumigation with phosphine, it exhibited significant effect on insect infestation and weight loss percentages, final germination percentage, seedling length, root length and seedlings fresh weights of wheat. The best results of insect infestation and weight loss percentages were obtained from samples of wheat seeds sealed stored in metal packages and fumigation with phosphine at the rate of 7 tablets/m^3 for 3 or 6 months (Tables 3 and 4). Although, maximum values of final germination percentage, seedling length, root length and seedlings fresh weights were obtained from samples of wheat and seeds sealed stored in metal packages and fumigation with phosphine at the rate of 5 tablets/m^3 for 3 months (Tables 5, 6, 7 and 8).

Table 4: Weight loss percentage as affected by the interaction among storage periods, storage methods and fumigation with phosphine.

Storage periods	Storage methods	Fumigation with phosphine			
		Untreated	3 Tablet /m^3	5 Tablet /m^3	7 Tablet /m^3
3 Months	Cotton bags	0.00	0.00	0.00	0.00
	Plastic jars	0.00	0.00	0.00	0.00
	Metal packages	0.00	0.00	0.00	0.00
6 Months	Cotton bags	18.90	18.23	17.06	16.50
	Plastic jars	18.30	17.63	16.73	16.33
	Metal packages	15.80	9.73	8.96	8.86
9 Months	Cotton bags	26.06	25.86	25.13	24.46
	Plastic jars	25.36	25.26	24.90	24.33
	Metal packages	18.10	17.46	16.40	15.73
F. test		*			
LSD at 5 %		0.50			

Table 5. Final germination percentage as affected by the interaction among storage periods, storage methods and fumigation with phosphine.

Storage periods	Storage methods	Fumigation with phosphine			
		Untreated	3 Tablet /m^3	5 Tablet /m^3	7 Tablet /m^3
3 Months	Cotton bags	87.3	88.3	91.6	90.3
	Plastic jars	86.5	86.7	90.0	88.6
	Metal packages	90.0	93.0	94.6	94.0
6 Months	Cotton bags	84.6	85.6	89.6	88.6
	Plastic jars	84.6	85.0	87.6	86.0
	Metal packages	85.3	87.6	90.0	90.0
9 Months	Cotton bags	81.3	85.3	89.0	86.6
	Plastic jars	80.0	85.0	87.3	85.3
	Metal packages	84.6	85.6	89.6	87.3
F. test		*			
LSD at 5 %		3.1			

Table 6. Seedling length (cm) as affected by the interaction among storage periods, storage methods and fumigation with phosphine.

Storage periods	Storage methods	Fumigation with phosphine			
		Untreated	3 Tablet /m^3	5 Tablet /m^3	7 Tablet /m^3
3 Months	Cotton bags	22.50	22.90	23.13	22.96
	Plastic jars	21.30	22.66	23.03	22.86
	Metal packages	22.66	23.23	23.46	23.26
6 Months	Cotton bags	21.70	21.73	22.16	21.93
	Plastic jars	20.76	21.10	21.46	21.26
	Metal packages	22.10	21.80	22.83	22.13
9 Months	Cotton bags	17.86	18.33	19.66	19.03
	Plastic jars	15.83	16.80	19.50	18.16
	Metal packages	17.86	18.66	20.60	19.03
F. test		*			
LSD at 5 %		0.72			

Table 7. Root length (cm) as affected by the interaction among storage periods, storage methods and fumigation with phosphine.

Storage periods	Storage methods	Fumigation with phosphine			
		Untreated	3 Tablet /m^3	5 Tablet /m^3	7 Tablet /m^3
3 Months	Cotton bags	15.33	15.43	15.66	15.50
	Plastic jars	15.13	15.26	15.56	15.43
	Metal packages	15.40	15.43	15.70	15.53
6 Months	Cotton bags	14.70	14.76	14.83	14.76
	Plastic jars	14.56	14.66	14.83	14.76
	Metal packages	14.80	14.83	15.23	15.10
9 Months	Cotton bags	14.36	14.46	14.60	14.56
	Plastic jars	14.33	14.43	14.60	14.53
	Metal packages	14.56	14.63	14.83	14.73
F. test		*			
LSD at 5 %		0.10			

Table 8. Seedlings fresh weight (g) as affected by the interaction among storage periods, storage methods and fumigation with phosphine.

Storage periods	Storage methods	Fumigation with phosphine			
		Untreated	3 Tablet /m^3	5 Tablet /m^3	7 Tablet /m^3
3 Months	Cotton bags	2.443	3.000	3.410	3.300
	Plastic jars	2.397	2.963	3.200	3.180
	Metal packages	2.533	3.167	3.383	3.333
6 Months	Cotton bags	2.403	2.780	3.187	3.130
	Plastic jars	2.380	2.710	3.023	2.987
	Metal packages	3.097	3.100	3.303	3.153
9 Months	Cotton bags	1.467	1.947	2.640	2.577
	Plastic jars	1.427	1.900	2.580	2.440
	Metal packages	1.833	2.347	2.743	2.633
F. test		*			
LSD at 5 %		0.244			

CONCLUSION

This study recommended that fumigation wheat seeds before storage in metal packages with phosphine at the rate of 5 tablets/m^3 under the environmental conditions of the experiment in Mansoura, Dakahlia Governorate, Egypt.

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تأثير طرق التخزين والتبخير بالفوسفين على فعالية التخزين وصفات إنبات وبادرات القمح خلال فترات التخزين المختلفة

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تم إجراء هذه التجربة تحت الظروف المعملية لوحدة بحوث تكنولوجيا البذور بالمنصورة معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، لدراسة تأثير طرق التخزين وتدخين التقاوى قبل تخزينها بالفوسفين بتركيزات مختلفة والتفاعل بينهما على فعالية التخزين، صفات الإنبات والبادرات لمحصول القمح خلال فترات التخزين المختلفة (٣ و ٦ و ٩ أشهر بعد الحصاد). تم إجراء التجربة في تصميم تجربة عاملية فى القطاعات العشوائية الكاملة (RCBD) فى أربعة مكررات. حيث تضمن العامل الأول فترات التخزين المختلفة (٣ و ٦ و ٩ أشهر بعد وقت الحصاد). وتضمن العامل الثاني طرق تخزين على النحو التالي؛ التخزين العادي (أكياس القطن) والتخزين المحكم الغلق (في عبوات بلاستيكية وعبوات معدنية). أما العامل الثالث فقد أشتمل على التبخير بالفوسفين بمعدلات صفر، ٣، ٥ و٧ أقراص/م٣ قبل بداية التخزين. ويمكن تلخيص أهم النتائج التي تم الحصول عليها على النحو التالي: - أدت زيادة فترات تخزين القمح من ٣ إلى ٦ و ٩ أشهر إلى التأثير المعنوى على صفات فعالية التخزين (النسبة المئوية للتقاوى المصابة والنسبة المئوية لفقد الوزن)، صفات الإنبات (النسبة المئوية النهائية للإنبات) وصفات البادرات (طول البادرة، طول الجذير، طول الريشة، الوزن الغض والجاف للبادرات). - سجلت أدنى نسبة مئوية للتقاوى المصابة ونسبة مئوية لفقد الوزن فى تقاوى القمح من التخزين فى عبوات معدنية محكمة الغلق ثم من التخزين في عبوات بلاستيكية. في حين، نتجت أعلى نسبة مئوية للتقاوى المصابة ونسبة مئوية لفقد الوزن من التخزين في أكياس القطن. سجلت أعلى نسبة مئوية نهائية للإنبات وأعلى القيم في صفات البادرات (طول البادرة، طول الجذير، طول الريشة، الوزن الغض والجاف للبادرات) من التخزين في عبوات معدنية محكمة الغلق، ثم من التقاوى المخزنة في أكياس القطن، في حين نتجت أدنى القيم من تلك الصفات من التخزين في عبوات بلاستيكية. - نتجت أدنى نسبة مئوية للتقاوى المصابة ونسبة مئوية لفقد الوزن من تبخير تقاوى القمح الفوسفين بمعدل ٧ أقراص/م٣. يليها الفوسفين بمعدل ٥ أقراص/م٣ ثم التبخير بالفوسفين بمعدل ٣ أقراص/م٣. بينما أعلى نسبة مئوية نهائية للإنبات وأعلى القيم في صفات البادرات قد نتجت من تبخير تقاوى القمح بالفوسفين بمعدل ٥ أقراص/م٣، يليها الفوسفين بمعدل ٧ أقراص/م٣ ثم التبخير بالفوسفين بمعدل ٣ أقراص/م٣. توصى هذه الدراسة بتبخير تقاوى القمح بمعدل ٥ أقراص/م٣ قبل تخزينها فى عبوات معدنية محكمة الغلق للحصول على أفضل كفاءة للتخزين وأيضاً أفضل صفات للإنبات والبادرات تحت الظروف البيئية للتجربة بمحافظة الدقهلية - مصر.