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STORAGE POTENTIALS AND TOLERANCE OF HIGH PROTEIN MAIZE (HPM) AND QUALITY PROTEIN MAIZE (QPM) TO SEED STORAGE PESTS IN CONTROLLED ENVIRONMENT

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Abstract: Studies on seed storage were conducted at seed processing and storage section of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan Nigeria in 2007 and 2008, to evaluate High protein maize (HPM) seed for resistance/tolerance to storage insect pest, and assess the resultant effect of seed treatment chemicals on its germination potential. Seeds of HPM variety (ART-98-SW1) and Quality protein maize (QPM) variety (ILE-1-OB) and two varieties of field corn (SUWAN-1-SR and TZPB-SRW) were treated with chemicals, namely Fitscophos^{TM}, Actellic 25 EC^{TM}, Apron Star^{TM} and combination of Actellic 25 EC and Fitscophos before storing them under controlled environment for six months. The results show that HPM, QPM and field corn require storage chemicals for effective storage, but both QPM and HPM varieties were significantly damaged by storage insect pests compared to field corn varieties regardless of the chemical used. Apron Star effectively reduced infestation by insect pests, but it may bring about significant reduction in seed viability if used for long term storage. Combination of Actellic 25 EC and Fitscophos successfully reduced infestation by insect pests without significant injurious effect on seed viability. Breeding programmes for resistance to storage pests is recommended while long term effects of Apron Star on seed viability needs to be investigated before recommending it for use in HPM/QPM maize varieties.

Key words: High protein maize, Quality protein maize, storage chemicals, storage insect pest

INTRODUCTION

Maize (*Zea mays*) is an important cereal crop ranking third after wheat and rice in production in the world (Onwueme and Sinha 1999). Although, maize production and utilization is rapidly dominating the farming system in Nigeria, normal maize protein is biologically poor compared to the nutritional value of 40% obtainable from milk (Bressani 1991). Like other cereal protein, field corn proteins are nutritionally poor for monogastric animals such as human being and pigs because of reduced content of essential amino acid such as lysine and tryptophan (Akande and Lamidi 2006). Quality protein maize on the other hand possessed twice the content of limiting amino acids (lysine and tryptophan) compared with conventional maize, and has been developed to reduce human malnutrition especially where maize is one of the major staple foods consumed by people. (Krivanek *et al.* 2006). Breeding efforts in QPM have been concentrated on yield potentials, reaction to prevailing diseases of the target environment, adaptation and improved nutritional quality of the evolving varieties (Akande and Lamidi 2006). Emphasis is placed less on the post harvest handling and storage potentials of the harvested seeds. Unlike other West African countries such as Ghana, adoption and cultivation of QPM is presently low in Nigeria (Akande and Lamidi 2006). Reasons for this include: poor storability of QPM seed, inadequate supply of seed, and susceptibility to diseases among others. Our experience in Institute of Agricultural Research and Training (I.A.R.&T.) Moor Plantation in Ibadan, is that storage pests, such as *Sitophilus zeamais* selectively destroy QPM while grain moth constituted a serious threat to storage of High protein (Oloyin) maize variety. It therefore became important to pay a serious attention to storage pests of these HPM and QPM varieties with a view to fashioning out a storage technique for evolving QPM seed. The need to evaluate the storage potentials of QPM seed using available storage chemicals, under controlled environment therefore becomes imperative. The objectives of this study therefore were to (I) comparatively evaluate HPM and QPM for resistance and tolerance to storage insect pests using conventional maize varieties as check and (II) to assess the resultant effect of the storage chemicals on germination potentials of HPM/QPM seed.

MATERIALS AND METHODS

A factorial experiment involving two factors (chemical type and maize variety) were used in a Completely randomized designed (CRD).The trial were set up in seed pro-

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cessing and storage section of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan Nigeria. Factor a (chemical type) has five levels while Factor b has four maize varieties.

One HPM seed (ART/98/SW1) and one QPM seed (ILE-1-OB) developed in the Institute of Agricultural Research and Training, Obafemi Awolowo University, and two normal maize varieties (SUWAN-1-SR and TZPB-SRW) developed by International Institute of Tropical Agriculture, (IITA) Ibadan were used for the experiment. Recommended dosage of storage and selected seed treatment chemicals were used. The seed treatment chemicals, Aluminum phosphide (Fitscophos), Pirimiphos methyl (Actellic 25 EC) and Thiamethoxam/Metalaxyl Difenonagole (Apron Star) were used to treat 200 carefully sorted clean maize seeds before storing them in air tight polyethylene bags for 6 months. The following code denotes each variety and treatment chemicals used:

- V_1= ART/98/SW1
- V_2 = ILE-1-OB
- V_3 = SUWAN-1-SR
- V_4 = TZPB-SRW
- C_0 = No chemical
- C_1 = Fitscophos only
- C_2 = Actellic 25EC only
- C_3 = Apron Star only
- C_4 = Fitscophos + Actellic 25EC

The trial was replicated three times and repeated twice (2007 dry season and 2008 wet season). Preliminary evaluation of the seeds was done before the commencement of the experiment to determine the initial seed quality (weight and viability). Data collected and evaluated at the end of six months in storage were:

1. Appearance rating: Scoring of 1 to 5 through visual assessment of seed lots
   1 = excellent
   2 = very good
   3 = good
   4 = fair
   5 = poor

$$2.\ \%\ \text{seed damaged} = \frac{\text{No. of seed damaged}}{\text{No. of seed stored}} \times 100$$

$$3.\ \%\ \text{weight loss} = \frac{\text{initial weight of stored seed} - \text{final weight of stored x 100}}{\text{initial weight of stored seed}}$$

$$4.\ \text{Average weight loss/Kernel} = \frac{\text{(total weight of undamaged seed)}}{\text{(No. of undamaged seed)}} - \frac{\text{(total weight of damaged seed)}}{\text{(No. damaged seed)}}$$

$$5.\ \%\ \text{seed viability lost} = \frac{\text{initial seed viability \%} - \text{final seed viability \% x 100}}{\text{initial viability \%}}$$

Percent seed viability was determined using ISTA procedure (ISTA 1996).

Data from the three replicates of the two year experiment were pulled together because of their similarity and subjected to analysis of variance using SPSS software package of 1999 and means were separated with New Duncan Multiple Range Test (Duncan 1955).

RESULTS AND DISCUSSION

Mean square (MS) for seed quality parameters are presented in table 1. Maize variety (V), treatment chemicals (C) and their interactions (V x C) were significant for appearance rating, and % seed damaged at $p < 0.05$. Similarly these sources of variations (V, C and V x C were significant for % seed viability loss at $p < 0.05$. However, % weight loss and average weight loss per kernel did not show significant effect at $p < 0.05$ among the maize seed varieties used. (Table 1). The significant differences observed in appearance rating, % seed damaged and % seed viability loss, suggests that High/Quality protein maize (QPM) and field corn maize differs in their storability potentials. They also react differently to storage chemicals. This might be due to varied genetic component of the QPM cultivars as reported by Vassal *et al.* (1993). It is also possible that lysine and tryptophan content of these maize varieties stimulate changes in seed appearance with time in storage.

Table 2 presents interactive means for variety x chemical interactions for seed appearance ratings. From these results, appearance rating of seeds treated with Apron star was significantly lower followed by those treated with combination of Fitscophos and Actellic 25 EC while seeds without chemical treatments recorded higher value of rating (Table 2). These results indicate that Apron Star was able to preserve maize seed for better appearance than other chemicals probably because of its combined fungicidal and insecticidal action. A similar result, by Adebisi *et al.* (2003) where soybean seed were treated with Apron plus had longer storage life span than untreated seed. The appearance ratings of ART/98/SW1 and ILE-1-OB without chemical treatment (4.00 and 3.87 respectively) were significantly higher than that of SUWAN-1-SR (3.13) and TZPB-SRW (3.00). Similarly, the appearance rating of HPM and QPM (ART/98/SW1 and ILE-1-OB) were higher than those of field corn regardless of the treatment chemicals. These results clearly confirm that QPM possesses a soft endosperm which is easier for insect pest to damage during storage (Vassal *et al.* 1993).

The interactive means of variety x chemical interactions for % seed damaged is presented in table 3. The results showed that seeds without chemical treatment suffered

Table 1. Mean square value for maize seed characteristics treated with storage chemicals

SV	Df	Appearance rating	% seed damaged	% weight loss	Average weight loss/ kernel	% seed viability loss
Variety [V]	3	0.84*	469.35*	1.70	0.02	5412.20*
Chemical [C]	4	5.61*	190.47*	1.91	0.02	3739.29*
Variety x Chemical [V x C]	12	0.18*	166.07*	1.67	0.01	222.01*
Error	60					
Total	79					

*significant at $p < 0.05$
Df – Degree of freedom

Table 2. Interactive means for variety x chemical interaction for seed appearance rating

Variety	No. Chemical	Fitscophos	Actellic 25 EC	Apron Star	Fitscophos + Actellic 25 EC	Mean	S.E.
ART/98/SW1	4.00	3.75	3.00	2.00	3.25	3.00	0.07
ILE-1-OB	3.89	3.87	3.00	2.63	3.50	3.75	0.07
SUWAN-1-SR	3.50	3.25	3.13	2.00	3.00	2.97	0.07
TZPB-SRW	3.50	3.37	3.12	2.13	2.87	3.00	0.07

S.E. – Standard Error

Table 3. Interactive means for variety x chemical interaction for % seed damaged

Variety	No. Chemical	Fitscophos	Actellic 25 EC	Apron Star	Fitscophos + Actellic 25 EC	Mean	S.E.
ART/98/SW1	5.50	5.00	3.63	2.44	3.88	4.08	0.78
ILE-1-OB	36.00	10.38	7.94	4.06	6.94	13.06	0.78
SUWAN-1-SR	5.06	4.00	4.94	2.81	4.94	4.34	0.78
TZPB-SRW	2.94	2.56	2.06	1.69	1.94	2.23	0.78

S.E. – Standard Error

Table 4. Interactive means for variety x chemical interaction for % seed viability loss

Variety	No. Chemical	Fitscophos	Actellic 25 EC	Apron Star	Fitscophos + Actellic 25 EC	Mean	S.E.
ART/98/SW1	53.78	15.77	7.75	11.12	12.53	20.19	0.07
ILE-1-OB	77.26	68.27	56.25	54.10	40.38	59.25	0.07
SUWAN-1-SR	62.23	39.70	34.23	23.46	17.92	35.52	0.07
TZPB-SRW	61.47	52.23	52.03	40.23	20.88	45.37	0.95

S.E. – Standard Error

Table 5. Maize seed characteristics as affected by seed treatment and storage chemicals

S.V.	Appearance rating	% seed damaged	% weight loss	Average weight loss/kernel	% seed viability loss
No. Chemical [C_0]	3.63 a	11.88 a	2.08 a	0.06 a	63.69 a
Fitscophos only [C_1]	3.56 a	5.48 b	1.11 b	0.03 b	43.99 b
Actellic 25 EC [C_2]	3.03 b	4.06 b	1.67 ab	0.03 b	37.59 c
Apron Star [C_3]	2.19 c	3.11 b	1.53 ab	0.03 b	32.23 d
Fitscophos + Actellic 25 EC [C_4]	3.41 a	5.14 b	1.68 ab	0.04 b	22.93 e

Means with same alphabets within the same column are not significantly different at $p < 0.05$
S.V. – Source of variation

Table 6. Means of maize seed characteristics

S.V.	Appearance rating	% seed damaged	% weight loss	Average weight loss/kernel	% seed viability loss
ART 98/SW1 [V_1]	3.30 a	4.35 b	1.99 a	0.29 b	45.37 b
ILE-1-OB [V_2]	3.38 a	13.06 a	1.36 a	0.34 ab	59.26 a
SUWAN-1-SR [V_3]	2.98 b	4.09 b	1.70 a	0.38 ab	20.20 d
TZPB-SRW [V_4]	3.00 b	2.24 b	1.41 a	0.06 a	35.53 c

Means with same alphabets within the same column are not significantly different at $p < 0.05$

a high degree of damage than those with chemical treatments. Percentage seed damaged of seeds of all the varieties treated with Apron Star was significantly lower, followed by seeds treated with combination of Fitscophos and Actellic 25 EC. ILE-1-OB was significantly damaged than other varieties regardless of the treatment chemicals (Table 3). The degree of damage in ART/98/SW1 followed that of ILE-1-OB under all chemical treatments except those treated with Apron Star and combination of Fitscophos and Actellic 25 EC where SUWAN-1-SR ranked next to ILE-1-OB. Percentage seed damaged of TZPB-SRW was the least for all treatments.

The interactive means for variety x chemical interactions for % seed viability loss are presented in table 4. From the result, % seed viability loss of seeds for all the varieties without chemical treatment (C_0) were significantly higher, followed by those treated with Fitscophos (C_1). Combination of Fitscophos with Actellic 25 EC gave lowest % seed viability loss in all the varieties except in ART/98/SW1 where treatment with only Actellic 25 EC gave lowest % seed viability loss (7.75%).

The effect of storage chemicals on seed characteristics are presented in table 5. Average weight loss per kernel, % seed damaged and % seed viability loss for maize seeds treated with chemicals was significantly different from those without chemical treatment (C_0). Furthermore, significant differences were also recorded in % seed viability loss among the seeds treated with different chemicals, whereas there was no significant difference between the results obtained for maize seeds treated with chemicals for seed damaged. Combination of Fitscophos and Actellic 25 EC was found superior resulting in least (22.93%) % seed viability loss, followed by Apron Star (32.23%).

Results obtained from the appearance rating and % seed damaged assumed the same trend. Seeds treated with Apron Star recorded lowest mean value of 2.19 and 3.11 for appearance rating and % seed damaged respectively. This was closely followed by seeds treated with Actellic 25 EC (3.03 and 4.06 for appearance rating and % seed damaged respectively). This result indicates that all the chemicals can significantly protect the seeds against storage pest but Actellic 25 EC was more suitable for seed storage because % seed viability loss was significantly reduced compared to Fitscophos and Apron Star treated seeds. Similar finding was reported by Gc (2006) where Actellic Super was found to be more effective in the control of storage pests of maize than Aluminium phosphide and common salt.

Table 6 presents character means for maize cultivars after storage. From these results, seeds of normal maize were generally better than HPM and QPM seeds in terms of storability and tolerance to storage pest. Appearance rating, % seed viability loss and % seed damaged of normal maize (SUWAN-1-SR and TZPB-SRW) were significantly different from that of the ART/98/SW1 and ILE-1-OB (HPM and QPM respectively). SUWAN-1-SR and TZPB-SRW recorded significantly lower scores of 2.98 and 3.00 respectively for appearance rating when compared with ART/98/SW1 and ILE-1-OB that recorded 3.30 and 3.38 respectively. Although, there was no significant difference between % seed damaged observed for ART/98/SW1, SUWAN-1-SR and TZPB-SRW. Mean of HPM seed (ART/98/SW1) still recorded higher value of 4.35 ranking next to ILE-1-OB that recorded significantly highest seed damaged of 13.08%. Similarly, % viability loss of ILE-1-OB (59.26) and ART/98/SW1 (45.37) were significantly higher than that of SUWAN-1-SR (20.20) and TZPB-SRW (35.58). This result clearly shows the superiority of normal maize over HPM and QPM in term of storability and tolerance to storage pest. National Research Council (1988) had reported that QPM varieties are known to be more vulnerable to diseases because of the soft, floury endosperm of the Opaque-2 maize. Also, Akande and Lamidi (2006) evaluated reaction of QPM to diseases and confirmed that QPM varieties are susceptible to fungal diseases. The soft endosperm of QPM is likely to be major factor responsible for its low level of tolerance to storage pest. Therefore, resistance to storage pest needs to be incorporated into QPM varieties through breeding programmes that will involve recombination of available QPM varieties with resistant normal maize varieties.

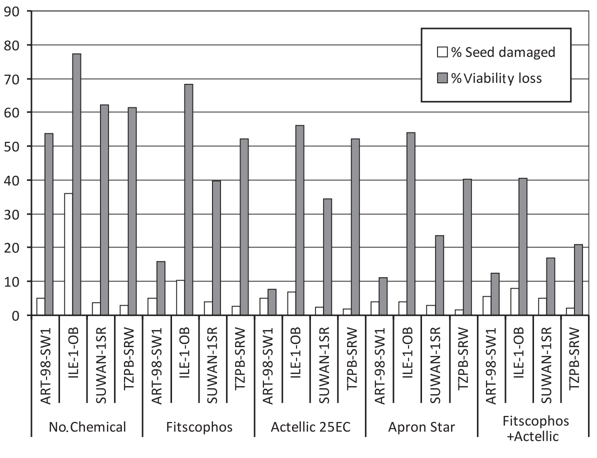

Fig. 1. Response of maize seeds to storage chemicals with respect to % seed damage and % seed viability loss

Response of maize seeds to storage chemicals with respect to % seed damaged and % seed viability loss are presented in figure 1. All the maize varieties tested requires chemical for effective seed storage. Seeds without chemical treatments were significantly damaged and recorded higher % viability loss (Fig. 1). ILE-1-OB losses viability and gets damaged easily compared to other varieties while TZPB-SRW resisted pest damage than other varieties under all chemical treatments (Fig. 1).

CONCLUSION

Results obtained from this study have shown that HPM and QPM seeds are susceptible to insect pest infestation and needs to be upgraded in breeding programmes to be able to resist insect pest during storage, as this will ensure availability of the seed and enhance its adoption. Available storage chemicals can effectively reduce insect pest infestation of HPM and QPM seed for short term storage but could not absolutely control it, most especially for long term storage.

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POLISH SUMMARY

POTENCJAŁ PRZECHOWYWANIA I TOLERANCJA WYSOKOBIAŁKOWEJ (HPM) ORAZ WYSOKIEJ JAKOŚCI (QPM) KUKURYDZY WOBEC SZKODNIKÓW PRZECHOWALNIANYCH W KONTROLOWANYM ŚRODOWISKU

W latach 2007 i 2008, w Instytucie Badań Rolniczych i Szkolenia, Uniwersytetu Obafemi Awolowo, przeprowadzono badania nad przechowywaniem nasion, w celu oceny odporności/tolerancji wysokobiałkowej kukurydzy na szkodniki przechowalniane i określenia efektu działania chemicznych zapraw nasiennych na potencjał ich kiełkowania. Nasiona odmiany HPM (ART-98-SW1) i kukurydzy o wysokiej jakości białka (QPM) (odmiana ILe-1-OB) oraz dwóch odmian kukurydzy polowej (SUWAN-1-SR i TZPB) traktowano środkami chemicznymi – preparatami: Fitscophos™, Actellic 25 EC™, Apron Star™ i kombinacją Actellic 25 EC i Fitscophos™ oraz Fitscophos, przed przechowywaniem ich w kontrolowanych warunkach otoczenia w ciągu sześciu miesięcy. Uzyskane wyniki pokazują, że HPM, QPM i kukurydza polowa wymagają użycia przechowalnianych środków chemicznych w celu uzyskania efektywnych wyników przechowania, ale zarówno odmiany QPM jak i HPM były istotnie uszkodzone przez szkodniki przechowalniane w porównaniu z odmianami kukurydzy polowej, bez względu na rodzaj użytego środka chemicznego. Apron Star istotnie zmniejsza zasiedlenie przez szkodniki przechowalniane, może również spowodować redukcję żywotności nasion, jeśli jest stosowany w przypadku długotrwałego przechowywania. Kombinacja Actellic 25 EC i Fitscophos ograniczyła z powodzeniem zasiedlenie przez szkodniki przechowalniane, bez istotnych uszkodzeń w zakresie żywotności nasion. Zaleca się prowadzenie prac hodowlanych w zakresie odporności na szkodniki przechowalniane, a długotrwały efekt preparatu Apron Star na żywotność nasion powinien być zbadany przed zaleceniem jego stosowania w przypadku odmian kukurydzy HPM/QPM.