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Impact of some essential plant oils on viability of stored cowpea and maize seeds for food security

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***Abstract*—Essential oils from three aromatic spice plants were applied on cowpea and maize seeds in storage and viability on germination was investigated. Cowpea and maize seeds were subjected to treatment using essential oils from (*Monodora myristica*, *Eugenia aromatic* and *Piper guineese*) at concentrations of 0, 5, 10, 15 and 20 ml/kg of seeds. These were stored at a temperature of 27±2ºC and 65 -70% r.h. in the laboratory. The viability test was conducted on the treated seeds at three and six months of storage, using Petri-dishes each containing 10 of randomly selected cowpea and maize seeds in three replicates, at the different levels of oil concentrations. The seeds were placed on moistened cotton wools and covered. Seeds germination occurred mainly within three to five days after commencement of experiment. The data obtained were subjected to two – way analysis of variance, at (p< 5%) using Ducan's multiple range test. It was observed that among the three essential oils applied, seeds treated with *Piper guineese* oil ranked highest in germinations at a concentration of 5 ml/kg for both seeds, with cowpea seeds having 88.7 and 83.0% and maize seeds with 69.3 and 45.3% at three and six months respectively.**

Keywords— cowpea, maize, food security, viability and essential oils

I. INTRODUCTION

Maize and Cowpea grains are major sources of calories and protein in the diet of Africans as well as most parts of the world. To achieve food security globally, farmers need seeds with high viability as planting materials. Delayed harvesting, improper seed storage, insect infestation as well as other contaminants are the major causes of reduction in seed viability [1].

Proper handling and post-harvest management are required for the production of healthy seeds for true foundation seeds, multiplication as planting materials, and high yield. The biological processes by microbes during storage and damages by insect pests result in a decline in seed viability. In sub-Saharan Africa, It is estimated that 25 – 40% grain losses occur at farm or village level during storage.

The conventional methods of insect pest control includes the use of fumigants, contact insecticides, anaerobic treatments and plant materials [2, 3]. Although synthetic insecticides have quick action and are effective in controlling insect pests, their health and environmental risks are of concern [4, 5]. The use of essential oils from plant products have not been exploited by the industries. As such, its application needs to be explored for food security beyond peasant farmers [6,7]. Essential oils are attributed to taint imparted to seeds under storage, as oils have been known to leave a persistence odour which could be unpleasant to insect [8]. Plant essential oils usage as crop protectants and as bio-insecticides are being considered acceptable replacement to synthetic insecticides for insect control as they leave no residue in the environment and has low mammalian toxicity [9,10]. Bio-insecticidal activity of different plant oils have been reported to suppress the oviposition of the *Callosobruchus maculatus* and significantly reduced cowpea damage [11, 12]. Also, some vegetable oil treatment reduced oviposition and progeny emergence, and has no effect on the adult's lifespan [12,13]; the highest dosage of 10 ml/kg protected the seeds for 5 months with no significant effect on viability [13]. Research findings showed that 50% of diluted oil of African nutmeg (*Monodora. myristica*) extract with ether admixed with cowpea did not reduce in seed viability after 3 months of application [14]. Nutmeg is believed to have antimicrobial, antifungal antioxidant and culinary properties. [15]. African black pepper (*Piper. guineese*) oil has high content of pepperine and this could be exploited for cowpea and maize storage. It is believed *P. guineese* is antioxidative and has culinary properties [16]. Cloves (*Eugenia aromatic*) are the aromatic flower buds of a tree in the family Myrtaceae, and clove oil has eugenol as its primary constituents has insecticidal effect and has been used to control cowpea and maize weevils. [17, 18] This study therefore examined the effect of essential plant oils from *M. myristica*, *E. aromatic* and *P. guineense* on the viability of stored maize and cowpea seeds that are widely grown and consumed in Nigeria.

II. MATERIALS AND METHODS

A. Sources of materials

Seeds of cowpea (Ife brown) and maize (Suwan I yellow), obtained from the Seed Unit of Institute of Agricultural Research and Training, Ibadan, Nigeria, while seeds of *M. myristica*, *E. aromatica* and *P. guineense* were sourced from a local market store in Akure, Nigeria.

B. Oil extraction and preparation of samples

The seeds of the plant materials were pulverized with MG 2053 Lexus Optimal stainless mixer / grinder, sieved with 600 µm mesh. Oil extractions were obtained by organic solvent extraction in 250 ml Soxhlet's apparatus using n – hexane (food grade) and were stored in an airtight container until usage. The cowpea and maize seeds were separately treated with the essential oils from (*M. myristica*, *E. aromatica* and *P. guineense)*, respectively at concentrations of 0 (control), 5, 10, 15 and 20 ml/kg of seeds under laboratory conditions of 27±2ºC and 65 -70% r.h. They were stored for 3 and 6 months in air tight containers. The experiment was conducted in a complete randomized design with fifteen treatments and three replicates.

At the end of 3 and 6 months of storage, 10 maize and cowpea seeds each were randomly selected and subjected to viability test, using Petri-dishes with lids (8.0 cm diameter) containing daily moistened cotton wool as the growth medium. The germination count was done for 7 days.

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C. Statistical analysis

The data obtained were subjected to two–way analysis of variance using SPSS version 21 [19]. The means were compared using Duncan's multiple range test at 5% probability level.

III. RESULTS AN DISCUSSION

Germination occurred on the third day for cowpea while that of maize was on the fifth day of the duration of the viability test.

A. Effect of plant oils on germination of Cowpea seeds

Germination of cowpea seeds at 3 months of treatment were significantly higher in control (95.3%) than in seeds treated with the essential oils (Table 1). Cowpea seeds treated with 5 ml *P. guineense* and *M. myristica* oils were significantly higher than other dosage levels of oil with viability of 88.7 and 81.3% respectively, which was higher than the value of 80% observed by [20]. Zero germination count was recorded on cowpea seeds treated with 15 and 20 ml *E. aromatica* oil, 20 ml *P. guineense* oil and 20 ml *M. myristica* oil; implying that higher concentrations of these essential oils impair seed viability. At 6 months of cowpea seed treatment, germination was similar to what was observed at 3 months as the germination percentage was significantly higher in the control with 5 ml *P. guineense* (83%) than in other essential oils. Also, no germination occurred in cowpea seeds treated with 15 and 20 ml of all the essential oils. *E. aromatica* oil is not suitable for cowpea storage owing to the low germination percentages recorded in this study while 5 ml of *M. myristica* oil and 5 ml of *P. guineense* proved effective for seed preservation at 3 and 6 months because of the high viability recorded. Generally, seed viability reduces with prolonged storage throughout the duration of the experiment. This is in contrast with the observation of [13] in application of vegetable oils that reported no significant difference in viability after 5 months of storage. This could be attributed to differences in bioactive ingredients of the essential oils compared to that of the vegetable oils.

B. Effect of plants oils on germination of maize seeds

At 3 months of maize seeds treatment, germination was significantly higher in the control (92%) compared with the seeds treated with the essential oils (Table 2).

Maize seed treated with 5 ml *P. guineense* oil gave significantly higher viability (69.3%) than in other oils, while its concentration at 10 ml and that of 5 ml *M. myristica* had 64% viability. The lowest germination (zero count) was recorded in maize seeds treated with 20 ml *E. aromatic* oil. The viability value obtained at 5 ml of *P. guineense* oil was quite lower than 75% observed by [20]. This might be due to varietal differences of the maize. At 6 months of treatment of maize seeds, the control had significantly higher viability of 67.5% and concentrations of 5 and 10 ml; *P. guineense* oil appeared to be significantly higher than others having values of 45.3 and 44% viability respectively It was observed that the germination in the control ranked highest next to 5 ml and 10 ml *P. guineense* oil which were significantly higher than other treatments. Except for 5 ml of *M. myristica* oil, very low viability was obtained at its higher concentrations and in all of *E. aromatica* oil, where it was zero germination for treatments at 10 and 20 ml, which was not significantly different from the 0.3% germination recorded from 15 ml. *P. guineense* oil is only suitable for seeds treatment at 5 ml not beyond 3 months. As observed with the cowpea seeds, viability of treated maize seeds were significantly reduced with prolong storage.

TABLE I. GERMINATION OF COWPEA SEEDS TREATED WITH DIFFERENT CONCENTRATIONS OF PLANT OILS

Plant oil	Concentration (ml)	Germination (%) (3 months)	Germination (%) (6 months)
Control	0	95.3^{h}	84.0^{f}
E. aromatica	5	12.7^{d}	1.3^{b}
	10	2.0^{b}	1.3^{b}
	15	0.0^{a}	0.0^{a}
	20	0.0^{a}	0.0^{a}
P. guineense	5	88.7^{g}	83.0^{f}
	10	23.3^{e}	2.7^{c}
	15	6.0^{c}	0.0^{a}
	20	0.0^{a}	0.0^{a}
M. myristica	5	81.3^{f}	21.3^{e}
	10	12.0^{d}	5.3^{d}
	15	2.0^{b}	0.0^{a}
	20	0.0^{a}	0.0^{a}

Means in each column followed by the same letter(s) are not different by Duncan's multiple range test ($p<5$).

TABLE II. GERMINATION OF MAIZE SEEDS TREATED WITH DIFFERENT CONCENTRATIONS OF PLANT OILS

Plant oil	Concentration (ml)	Germination (%) (3 months)	Germination (%) (6 months)
Control	0	92.0^{h}	67.5^{g}
E. aromatica	5	6.7^{d}	6.7^{c}
	10	4.0^{bcd}	0.0^{a}
	15	1.3^{ab}	0.3^{a}
	20	0.0^{a}	0.0^{a}
P. guineense	5	69.3^{f}	45.3^{f}
	10	64.0^{f}	44.0^{f}
	15	45.3^{e}	38.0^{e}
	20	5.7^{bcd}	3.3^{b}
M. myristica	5	64.0^{f}	34.7^{d}
	10	9.0^{e}	8.3^{c}
	15	6.3^{cd}	4.0^{bc}
	20	4.0^{bcd}	2.3^{b}

Means in each column followed by the same letter(s) are not different by Duncan's multiple range test ($p<5$).

Fig. 1 gives a graphical presentation of cowpea and maize germination response to the treatment with these essential oils; at 5 ml *concentrations, P. guineense* performs favourably to the control at 3 months for both seeds viability while *M. myristica* has high viability

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only on cowpea. The plant oils investigated in this experiment adversely affected the germinability of treated cowpea and maize seeds carried out at 3 and 6 months later at higher concentrations. In situations, where seeds treated at higher dosage rate of 20 ml *E. aromatic* oil had zero viability at 3 and 6 months after treatment /storage. This could be a disadvantage as seeds which farmers may desire to preserve for future planting cannot be protected with higher concentrations of the oils. This could be due to the toxicity of the active ingredients possessed by the oils at higher concentrations, which might have soiled and caused the death of the embryo of the seeds during the period of storage and also due to the problems with the taint

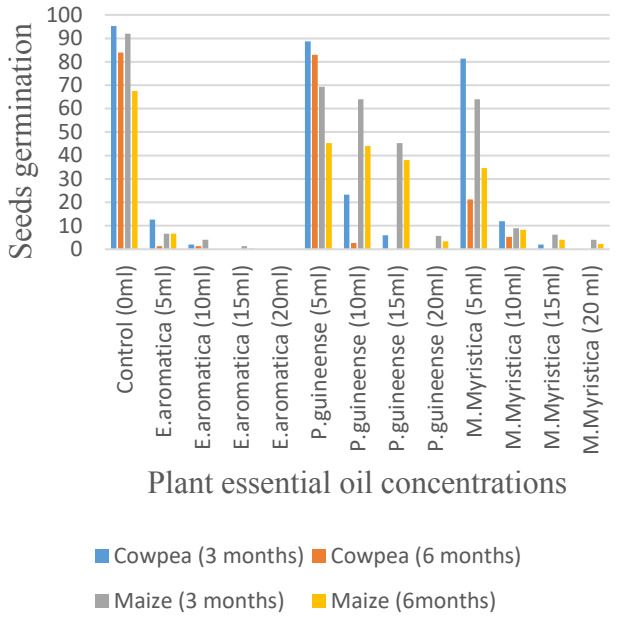

Fig. 1. Seeds germination response versus plant essential oil concentration.

as off – colours which the seeds would have sucked into the cotyledons through the outer coat layer of the seeds.

IV. CONCLUSION

The control at 0 ml concentration, had higher seed viability among all the treatments, though percentage of gemination reduces with duration of storage; obviously, cowpea and maize seeds had high viability when preserved with oils at lower dosage rate of (5 – 10 ml); the adverse effects on viability of seeds occur at higher concentrations, and it is advantageous as they can be used as protectants on grains that are not meant for planting but for consumption of processed products as reported by [21].

It has been established that once essential oils are applied to the seeds, the activity of the plant oils can last up to six months, as it is important as storage conditions by rural farmers in Africa are liable to re-infestation after first treatment of seeds, usually this can be high due to poor storage sanitation. The application of *P. guineense* and *M. myristica* is recommended as protectant for cowpea and maize seeds not beyond 3 months for planting at 5 concentrations while higher dosages will serve as protectants up to 6 months for use in food preparation to enhance food security. These findings can be applied for medium scale storage for essential oils to be safely introduced to integrated pest management beyond peasant farmers for grain protection.

Future studies are needed to characterize the active compounds in the tested essential oils that have the insecticidal effects.

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