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COMPARATIVE EFFICACY OF BOTANICAL EXTRACTS AGAINST STORAGE WEEVILS OF MAIZE (*Zea mays* L)

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ABSTRACT

Seeds of two maize varieties (Suwan-1-SRY and TZPBSR) were initially evaluated for seed moisture content, germination and Seedling Vigour Index. 50g cleaned, undamaged, uninfested seeds from each seed lot were treated with different botanical extracts from five plant materials (Neem leaf powder, Ocimum leaf powder, Chromolaena leaf powder, Tithonia leaf powder and *Piper guineense* ground powder) and actellic liquid to give six treatments and one control at recommended dosages. Artificial infestation was carried out with five pairs of newly emerged unsexed adults of *Sitophilus zeamais* for 14 days after which they were removed. The jars covered with wire mesh and held with rubber bands arranged in a completely randomised design in the laboratory for 12 weeks using three replications. Data were collected on initial and final seed sample weight, number of emerged adults, total number of adult mortality, number of damaged and undamaged seeds and total number of holes per sample. Seeds in storage were also tested for seed viability and vigour. Data collected were subjected to analysis of variance (ANOVA). The initial germination test showed a significant difference between the two maize varieties. All the plant products applied to maize grains significantly reduced weight loss in the grain when exposed to *S. zeamais.* The plant products tested in this study were also significantly effective on the adult maize weevils. The chemically treated samples and the plant products recorded more as against the non-treated sample. Suwan-1-SRY had the least % weight loss. In terms of plant extracts' effect on seed germination and seedling vigour, basil was most effective; followed by Chromolaena, actellic, Piper, Tithonia and neem. Results thus indicated efficacy of the various plant products and spices as grain protectants in storage pest management. Botanical pesticides thus represent an important potential for integrated pest management programmes in developing countries.

Keywords: Maize weevils, Botanical extracts, Seed characters.

INTRODUCTION

Maize *(Zea mays)* is an important food crop in tropical countries especially in Africa where it is a cheap source of dietary carbohydrate. The crop ranks second to wheat among the world's cereal crops and its global production exceeds 400 million tonnes per year, compared with almost 500 million tonnes of wheat and less than 400 million tonnes of rice. In the developing countries, maize ranks third, after rice and wheat and 40% of the total global maize production is realized on 60% of the world's maize area of about 80million hectares (CIMMYT, 1994). Maize is high yielding, matures early, easy to process, readily digestible, costs less than other cereals and can be grown across a wide range of agro ecological zones (Enyong *et al*., 1999), it is widely cultivated throughout the World, and more quantity of maize is produced each year than any other grain (David, 1985).

In the pre- and post- harvest period, stored crop products are usually liable to depreciation by pest organisms especially insects. Most important storage pests are Coleopterans and Lepidopterans.

Estimate of post harvest crop losses worldwide has been given as 10-20% but 25-40% for the tropics by other researchers (Hill and Waller, 1990). In storage, *Callosobruchus maculatus* causes a major loss; infestation of stored cowpea could be as much as 98% in markets and village stores (Albeck, 1996). Post harvest losses to storage pests such as the maize weevil (*Sitophilus zeamais* Motch) have been recognized as an increasingly important constraint in Africa (Boumas, 1985).The magnitude of damage that can occur depends on factors such as the kind of crop and insect storage (Hill and Waller, 1990). Delima (1987) reported that insect pest problems in the tropical storage environment are greater than those in the temperate climates, presumably because of optimal conditions of temperature and humidity for pest development found in the former.

Grain quality is related to its appearance, uniformity, sanitary conditions, nutritional status and industrial characteristics. Damage caused by insects, moulds, and mishandling result in losses of quality and quantity in storage. Such losses are frequently not precisely estimated because of the difficulties involved in such endeavours; the grading system is based on discreet measurements of quality, with little attention given to the quantity losses (Kenkel *et al*., 1997). Ever since man learned to conserve agricultural produce in order to provide food from one season to the next, insects and rodents have made degradation on such stored food. Today, stored grains in the tropics continue to suffer serious damage and losses particularly through the attack of *Tribolium castaneum*, while *Tribolium confusum* do the same in the sub-tropical and temperate regions (Kenkel *et al*., 1997).

It is well established that insects are by far the most destructive of all the pests. They cause the greatest losses of harvested crops, especially during storage. They perforate and consume the stored grain, their larvae grow inside the produce and the general damage they do reduce percentage viability and hence the following season's crops. The insect damages on stored products consist mainly on the reduction of dry matter food, contamination with live or dead insects, fragments, and depreciation of the nutritional and commercial values of the end products. The food industry adopts rigid standards concerning the presence of live insects and their fragments in all kinds of foods. Faroni (1992) reported that one larva of rice weevil, *Sitophilus oryzae* (L), (Coleoptera, Curculionidae), during its growth, metabolises about 14mg of a single wheat kernel into carbon dioxide, water, heat and excrements, and the insect consumes about two thirds of the endosperm.

If insect pests of agricultural products are effectively controlled, there could be an immediate increase in food available worldwide, without much change in agricultural productivity. It has been postulated that if the world food losses is reduced by half, 40 million more tones of cereals would be saved or made available for utilization (FAO, 1979). The management of quality should, therefore, consider temperature variations, insect population fluctuation and the type of damages in order to establish an appropriate control (Subrahmanyan, 2000). Under favourable conditions, most stored product insect pests will complete their life cycle in 4-6 weeks and may lay over 100 eggs. Other factors that help their success are their wide range of food and environmental tolerance, since they are securely hidden or close to their food source.

Currently, in Nigeria, weevil attack still causes over 40% losses of stored maize and sorghum, while the loss of beans in storage may be as high as 60% unless careful precautions are taken. Hence, the need for effective and efficient storage systems and techniques. Damage by the maize weevil, *Sitophilus zeamais* in storage can cause complete damage within few months of storage and infestation of grains mostly take place before harvest or during harvest and in storage. Post harvest losses to storage pests such as the maize weevil have been recognized as an increasingly important constraint in Africa (Bourne, 1997). Other major storage insects of maize include: - Lesser grain borer (*Rhyzopertha dominica*), Red flour beetle (*Tribolium species*), and Angoumois grain moth (*Sitrotoga careallela*) among others.

The modern day storage is not complete without mentioning the role of chemicals used as insecticides or rodenticides as both protective and preventive means. The insecticides may be applied in form of dust, fumigants, or wettable powders. This idea stemmed out of the alternative methods being used by the peasant ancient farmers such as wood ashes, vegetable oils etc. And the role of this cannot be over emphasized in ensuring seed life longevity and prevention of infestation since about 30-50% of grain stored by peasant farmers is routinely lost to pests (Apeji, 2000).

The objectives of the study were to:

(i) Evaluate the relative effects of some botanical extracts on maize weevil (*Sitophilus zeamais*).
(ii) Evaluate the comparative effectiveness of the botanical extracts and
(iii) Evaluate the inhibitory effects of the botanical extracts on germination and seedling vigour of maize seeds.

MATERIALS AND METHODS

This study was conducted at the Entomological Research Laboratory of the Department of Crop Protection, College of Plant Science and Crop Production, University of Agriculture, Abeokuta, Ogun State, Nigeria.

Insect Culture

The maize weevil, *Sitophilus zeamais,* used for the study was obtained from the Organic Agriculture Farm, University of Agriculture, Abeokuta and cultured in glass jars in the laboratory of the Department of Plant Breeding and Seed Technology, College of Plant Science and Crop Production, University of Agriculture, Abeokuta, using maize seeds.

Source of Maize

The two maize varieties used for this study Suwan 1 and TZPBSR were collected from Organic Agriculture and the Department of Plant Breeding and Seed Technology, respectively both in Federal University of Agriculture, Abeokuta, Ogun State. The maize varieties were fumigated to get rid of any insect or pathogen.

Treatment Materials

The treatment materials used in this experiment include: Actellic liquid and five plant materials (Neem leaf powder, Ocimum leaf powder, Chromolaena leaf powder, Tithonia leaf powder and *Piper guineense* ground powder).

Collection and extraction of plant products

The leaves of the plants and *Piper guineense* (black pepper) dry seeds were collected from Abeokuta, Ogun State, Nigeria. The leaves of the plants and black pepper seeds were air dried and grounded into fine powder using mortar and pestle, sieved and stored in polyethylene bags until required.

Experimental Procedure

Seeds of the two maize varieties were sorted manually to remove broken seeds, particles, inert matters, other crop seeds, weeds and damaged seeds. Seed moisture content was determined by oven-dry method and estimated on fresh weight basis. Germination test was carried out using the standard germination procedure; while Seedling Vigour Index of the two maize varieties was then evaluated as: percent germination x seedling length (where seedling length is a measure of the length of the plumule from the base of the germinated seed to the apex of the longest foliage). A 50g cleaned, undamaged, uninfested seeds from each seed lot were weighed into 150cm^3 capacity glass jars. A 5g of each botanical powder was mixed with the cleaned weighed seeds and actellic liquid at a recommended rate of 16 – 40 ml in 1 – 2 litres of water per 1,000kg produce according to the manual. Artificial infestation was carried out with five pairs of newly emerged unsexed adults of *S. zeamais* for 14 days after which they were removed. The jars were covered with wire mesh held with rubber bands. Each experiment was replicated thrice and arranged in a completely randomised design in the laboratory for 12 weeks. The last batch serves as the control experiment.

Data collection

The following data were collected at 12 weeks after storage.

- Initial and final seed sample weight
- Number of emerged adults
- Total number of adult mortality
- Number of damaged and undamaged seeds
- Total number of holes per sample
- Germination test
- Seedling vigour index = % germination x seedling length
- Percentage weight loss =

$$\frac{\text{Initial weight - Final weight of seed after storage}}{\text{Initial weight of seed before seed Treatment}} \times 100$$

- Percentage seed damage =

$$\frac{\text{Number of damaged seeds}}{\text{Number of undamaged seeds}} \times 100$$

Data analysis

Data collected were subjected to analysis of variance (ANOVA). Means separation was also carried out using the Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Initial Seed Quality Test

Results of the initial germination test carried out on the seed lots to ascertain their basal quality before application of treatments were shown in Table 1. The germination percent in Suwan-1-SRY was significantly higher than in TZPBSR which were 97.33% and 28% respectively. The result of the moisture content determination (Table 1) also showed that the moisture content of the seeds of the two maize varieties were not significantly different. The differences in the initial germination test result might be due to differences in period of production as there was no information on pre-storage history of the two varieties.

Effect of seed treatments on seed quality characters of the two maize varieties

The mean squares of seed characters evaluated for two maize varieties under seven treatments are shown in Tables 2 and 3.

The result showed that the effect of variety was significant for final weight and highly significant ($P \leq 0.01$) for all other quality characters expect for initial weight and percentage weight loss. Treatment was highly significant ($P \leq 0.01$) for all the characters expect for percentage weight loss where it is significant while Var X Trt was significant only for damaged seeds and percentage damaged seeds (Table 2).

Table 1: Initial quality of maize varieties used

Variety	Moisture Content (%)	Germination (%)
Suwan 1	8.76	97.33
TZPBSR	8.18	28

Table 2: Mean squares from analysis of variance of six seed characters evaluated for two maize varieties under seven seed treatments.

Source	df	iniwt	finwt	percwtloss	dmgseed	undmgseed	percdmgseed
Rep	2	0.016	0.28	3.39	2.64	35.31	0.79
Var	1	0.00	5.24*	13.79	148.58**	414.86**	37.35**
Trt	6	0.01	6.01**	21.20**	56.47**	234.13**	14.31**
Var x Trt	6	0.01	0.92	4.16	15.15*	57.02	3.65*
Error	26	0.00	0.72	3.73	5.00	55.85	1.26
Total	41						

Key: **= significant at 1% level of probability, *= significant at 5% level of probability, ini wt= initial weight, fin wt =final weight, percwtloss= percentage weight loss, dmg = no of damaged seeds, no of undmgseed = undamaged seeds, percdamgseed = percentage damaged seeds, df= degree of freedom.

The effect of variety was highly significant ($P \leq 0.01$) for all the seed quality characters evaluated expect for total number of adult mortality where it was significant ($P \leq 0.05$) while the effect of treatment was highly significant for all the five seed characters evaluated ($P \leq 0.01$) (table 3). The effects of variety and treatment interaction was highly significant ($P \leq 0.01$) for final germination (%) and seedling vigour index while it was significant for number of holes and number of emerged adults and not significant for total number of adult mortality (Table 3).

Effect of maize variety on seed quality characters subjected to seven seed treatments

Means of seed quality characters evaluated for the two maize varieties are presented in Tables 4, 5, 6 and 7. Highest undamaged seeds (199.33) were recorded with Suwan 1 followed by TZPBSR (19.05). Highest damaged seeds (7.24) were recorded with TZPBSR which was significantly different

Table 3: Mean squares of five seed characters evaluated for two maize varieties under seven seed treatments.

Source	df	No of holes per sample	No of emerged adults	Total no of adult mortality	Final germ (%)	SVI
Rep	2	2.88	7.31	0.67	28.95	5734.94
Var	1	160.10**	97.52**	25.93**	57942.86**	27033241.79**
Trt	6	56.77**	170.58**	35.07**	1068.19**	962001.47**
Var x trt	6	16.32**	30.25*	7.98	739.30**	653932.03**
Error	26	5.14	9.36	5.74	60.95	8157.67
Total	41					

Key: **=significant at 1 % level of probability, *= significant at 5 % level of probability, germ. = germination, SVI= seedling vigour index, df= degree of freedom.

from Suwan 1 (1.75). There was no difference in the percentage weight loss in the two varieties (Table 4). The seedling vigour index of Suwan 1 (1698.08) was the highest while TZPBSR (93.52) recorded the lowest. Similarly, final germination (%) for Suwan 1 was significantly higher (88.95) than TZPBSR (14.67). TZPBSR recorded the highest total number of adult mortality (6.81) while Suwan 1 recorded the lowest (5.24). Total number of emerged adults of TZPBSR (10.71) was significantly higher than Suwan 1(7.67). Similarly, TZPBSR recorded the highest number of holes per sample (7.33) while Suwan 1 recorded the lowest (3.43) (Table 5).

Seeds treated with actellic liquid recorded the highest number of undamaged seeds(205.50) with no damaged seeds (0.00) which is significantly different from other treatments followed by piper which recorded (201.67) with (5.83) of damaged seeds. Basil recorded the highest weight loss (%) which was significantly different from all other treatments followed by Piper (2.58) and Titho (3.51)

Table 4: Means of six seed characters evaluated for two maize varieties subjected to seven seed treatments

	Initial weight	Final weight	Weight loss (%)	No of damaged seeds	No of undamaged seeds	Weight loss (%)
SUWAN -1	50.19a	48.68a	3.012a	3.48b	199.33a	1.75b
TZPBSR	50.20a	47.97b	4.16a	7.24a	193.05b	3.63a

a,b, Means followed by the same letters are not significantly different along the columns.

Table 5: Means of five seed characters evaluated for two maize varieties subjected to seven seed treatments

Maize varieties	No of holes per sample	No of emerged adults	Total no of adult mortality	Final germination (%)	Seedling vigour index
SUWAN -1	3.43b	7.67b	5.24b	88.95a	1698.08a
TZPBSR	7.33a	10.71a	6.81a	14.67b	93.52b

a,b, Means followed by the same letters are not significantly different along the columns according to Duncan Multiple Range Test.

which were not significantly different while Chrom (4.12), Neem (4.56) and the control are intermediate but Actel recorded the least weight loss (0.09). Actel has the least number of damaged seeds (0.00) is significantly different from all other treatments while Control recorded the highest (9.83) followed by Basil (7.17). Piper and Chrom (5.00) are not significantly different from each other. Titho was intermediate among the treatments with (3.50). Percentage damaged seeds was highest in Control (4.92) followed by seeds treated with Basil (3.67) and Neem (3.12), Piper (2.87) and Chrom (2.50) which are not significantly different from each other while Titho recorded the least (1.75) (Table 6).

Means of each seed treatment materials on five seed quality characters evaluated for the two maize varieties is also presented in table 7. Seeds treated with Basil recorded the highest seedling vigour index (1317.95) followed by seeds treated with Chrom and the Control which are significantly lower with 1203.02 and 1134.95 respectively than seeds treated with Basil. Seeds treated with Neem recorded the least seedling vigour index

Table 6: Means of seven seed treatment for the control of storage weevils for six seed characters evaluated for two maize varieties

Seed treatment	Initial weight	Final weight	Weight loss (%)	No of damaged seeds	No of undamaged seeds	Damaged seeds (%)
Piper	50.25a	48.95b	2.58b	5.83cb	201.67ab	2.87bc
Chrom	50.16ab	48.06cbd	4.12ab	5.00cb	194.67cd	2.50bc
Titho	50.12b	48.36bc	3.51b	3.50c	198.00abc	1.75c
Neem	50.25a	47.51cd	4.56ab	6.17cb	196.00abcd	3.12bc
Basil	50.17ab	47.10d	6.11a	7.17b	188.00d	3.67ab
Actel	50.20ab	50.15a	0.09c	0.00d	205.50a	0.00d
Control	50.21ab	48.12cbd	4.16ab	9.83a	189.50cd	4.92a

a,b,c,d Means followed by the same letters are not significantly different along the columns.
Key: Piper= *Piper guineense*, Chrom= *Chromolaena odorata*, Titho= *Tithonia diversifolia*, Basil= Ocimum, Actel= actellic liquid.

Table 7: Means of seven seed treatment for the control of storage weevils for five seed characters evaluated for two maize varieties

Maize varieties	No of holes per sample	No of emerged adults	Total no of adult mortality	Final germination (%)	Seedling vigour index
Piper	5.83bc	4.33d	3.00d	50.00cb	853.00d
Chrom	5.00bc	10.83bc	4.50cd	59.33b	1203.02b
Titho	3.50c	10.00c	5.67bcd	46.67c	618.09e
Neem	6.33bc	10.00c	7.83ab	28.00d	157.49f
Basil	7.17ab	14.17ab	7.00bc	71.33a	1317.95a
Actel	0.00d	0.00e	10.00a	50.00bc	986.11c
Control	9.83a	15.00a	4.17cd	57.33b	1134.95b

a,b,c,d, Means followed by the same letters are not significantly different along the columns.
Key: Piper= *Piper guineense,* Chrom= *Chromolaena odorata*, Titho= *Tithonia diversifolia*, Basil= Ocimum, Actel= actellic liquid.,

(28.00) followed by Titho (46.67). The highest seedling vigour index was recorded in seeds treated with Basil (71.33) followed by seeds treated with Chrom (59.33) but this was not significantly differently from the Control (57.33). Seeds treated with Actellic liquid had moderate final germination (%) (50.00) followed by seeds treated with Piper (50.00) and seeds treated with Titho which was significantly lower (46.67).

Effect of Seed Treatment on Seed Germination and Seedling Vigour

Results of the effect of seed treatment on germination of Suwan 1 and TZPBSR seed lots are presented in figures 1 and 2 respectively. Piper has the highest % germination which was significantly different from other treatments. Basil, Chrom, Actel are not significantly different from each other. Neem has the lowest % germination followed by Titho for Suwan-1 while for TZPBSR; Basil has the highest which was significantly different from other treatments. Actel recorded the least % germination.

Figures 3 and 4 show the effect of treatment on Seedling Vigour Index for Suwan 1 and TZPBSR respectively. Control recorded the highest Seedling vigour index for Suwan 1 followed by Basil and Chrom which was not significantly different from each other.

Neem recorded the least. For TZPBSR, Basil recorded the highest Seedling vigour index which was significantly different from other treatments while Titho recorded the least.

All the plant products tested in this study were effective and recorded adult maize weevil mortality to some extent. Normally, the plant products do not have specific insecticidal effects, but their toxicity may be attributed to fumigation effect, repellency or stomach poison effect in cases where weevils feed on admixed grains (Dales, 1996).

The chemically treated samples and the plant products recorded more germination percentage. This is similar to the observations of Pal and Basu (1993) who reported that neem leaf powder has seed invigorating properties in spite of its insecticidal properties. It was also observed that differential effect of the treatment materials on the seed quality of the varieties were marginal. This is a reflection of the high seed quality following production processes especially Suwan-1.

In terms of reduction of percentage weight loss caused by weevils, all the plant products used had appreciable effects. Among the maize varieties, Suwan 1 was observed to have the least % weight loss. This can be said to be as a result of high initial quality of the seed. Also, the percentage of maize damaged caused by *S. zeamais* varies among the varieties of maize. It was observed that the highest damage was recorded in the variety TZPBZR and the lowest percentage was recorded in the variety Suwan 1. This implies that there were variations in damage caused by *S. zeamais* among the maize varieties.

Number of holes is a symptom of damage as the grain will have reduced market value and germination potential. All grains treated with the plant products had reduced considerably number of holes than the untreated control. This reduction could be attributed to low adult weevil mortality and high adult weevil emergence in untreated control.

Plant product treatments of grains has no effect on the viability of seeds. Therefore, such plant products could reduce the effect on grain quality provided the seeds have high initial quality seeds and are of good genetic make up.

At higher moisture contents, seeds tend to lose their ability to germinate in storage and become damaged easily as a result of infestation by insects. Maize may be harvested at moisture content well above the safe level of below 15% moisture content desirable before removing grains/seeds from cobs. The moisture content affect respiration rate of seeds and increased to a moisture level above 20% increases micro-organism growth which may produce heat rapidly enough to kill the seeds (Bradenburg, 1996).

Therefore, if the moisture content of the seeds used in this experiment has been high then more damage could have been reported, likewise the incidence of more insect emergence. This is supported by Bradenburg, 1996 who reported insect damage to be related to seed moisture. It was discovered that most of the weevils and insects could not breed at levels below 8%.

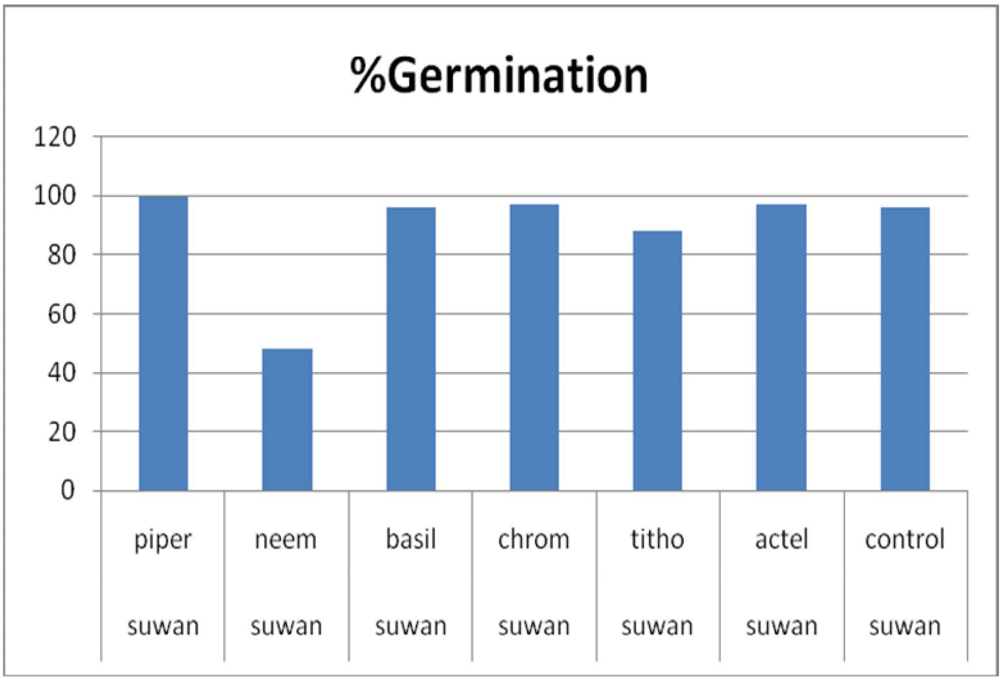

Fig.1: Percentage germination of Suwan-1- SRY seeds subjected to seven seed treatments

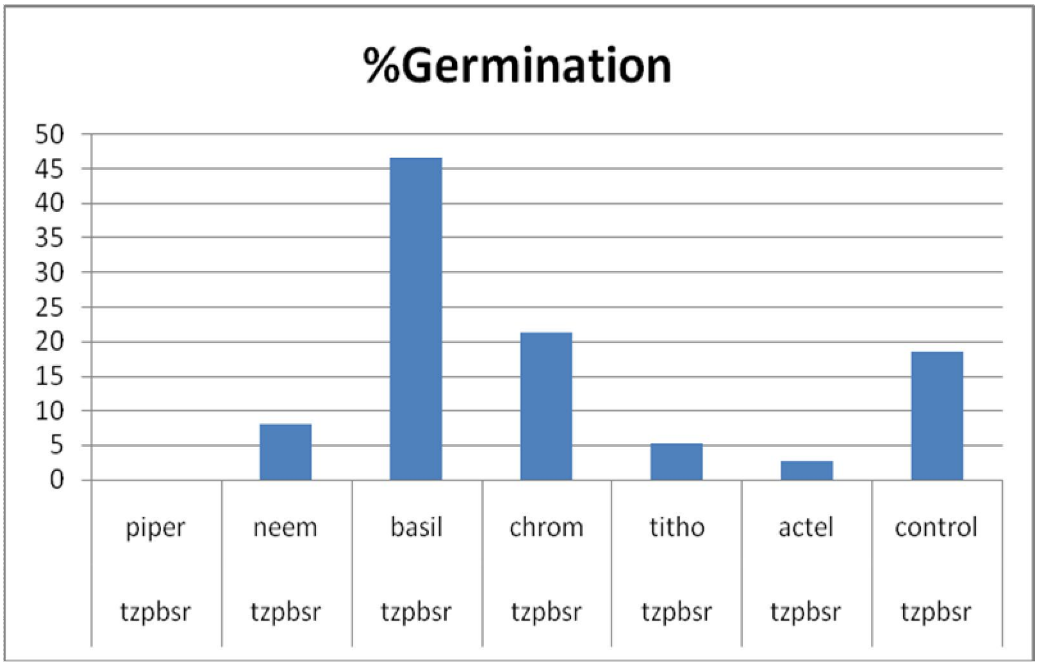

Fig.2: Percentage germination of TZPBSR seeds subjected to seven seed treatments

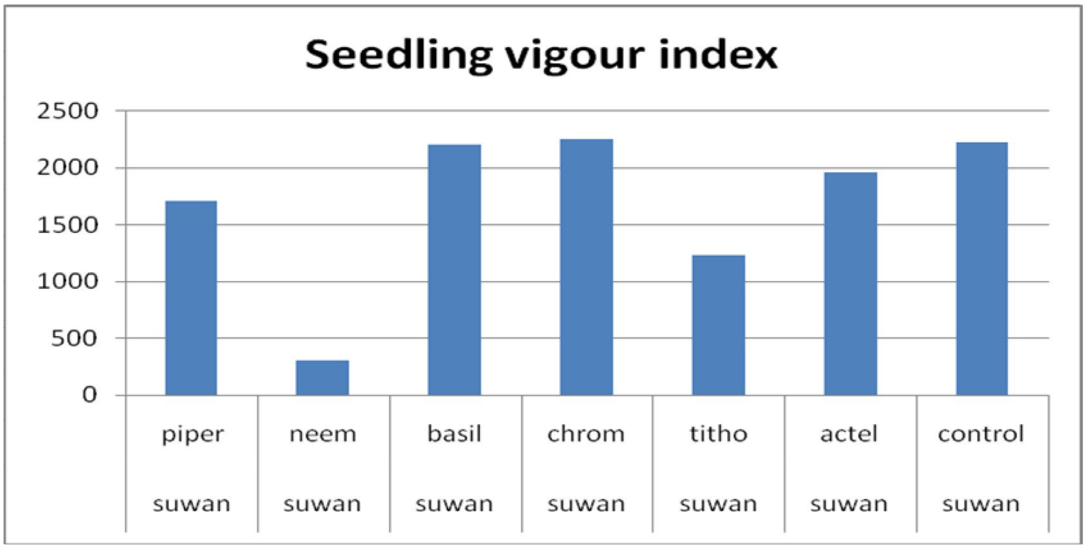

Fig.3: Seedling vigour index of Suwan-1-SRY seeds subjected to seven seed treatments

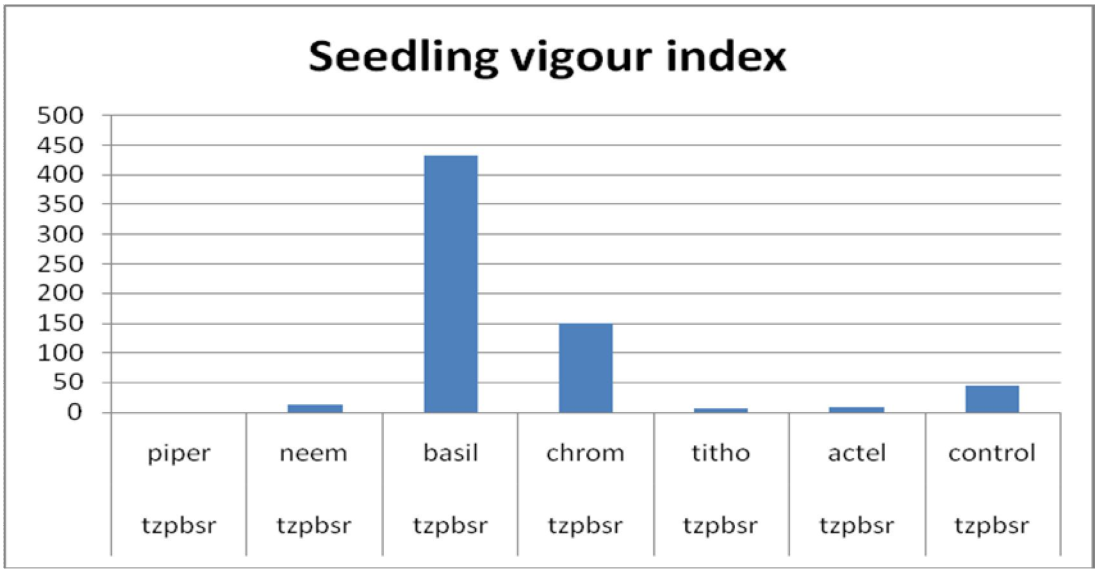

Fig.4: Seedling vigour index of TZPBSR seeds subjected to seven seed treatments

CONCLUSION

The results obtained in this study indicated good potential of using Neem leaf powder, Ocimum leaf powder, Chromolaena leaf powder, Tithonia leaf powder and *Piper guineense* ground powder as effective grain protectants in storage pest management systems. The plant products are broad spectrum in pest control, readily available, safe to apply and can be afforded by resource poor farmers. Botanical pesticides, thus, represents an important potential for integrated pest management programmes in developing countries as they are based on local materials.

There are practical implications of this study to resource poor farmers in sub-Saharan Africa. Future work being undertaken on possible combination of the plant products for protection of stored maize would add to the development of traditional pesticides at the farm level for resource poor farmers who have no access to or can afford commercial pesticides and which has no adverse effect on consuming stored products with which they are stored. Also, further trials are recommended on a wide range of storage insect pests to adequately advise farmers and policy makers. Under small-scale farmer conditions, powdered treatments may protect stored grains for the time being. However, to enhance the toxic effect of the plant materials, further investigations are required particularly on chemical composition of the plant and methods of formulation of the active plant material.

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