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Efficacy of Lemon Extracts in Controlling Mealy Bugs of Stored Yam (*Dioscorea rotundata*)

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ABSTRACT

Background: The use of plant extracts in controlling mealy bugs is widespread especially on stored products. Despite this, research on lemon extracts, which is known to be very effective against some insect pests are limited. We assessed the repellent ability of lemon extracts in controlling mealy bug infestation and observed if there was any added benefit of the extract in retarding sprouting of yams in storage.

Methods: We used the complete randomized design with three treatments and three replications. The treatments consisted of lemon peels, lemon leaf extracts and a control. Ten tubers of Pona white yam variety were rubbed on the periderm with each treatment and placed on a shelf. Two yam tubers naturally infested with mealy bugs were placed at the edges of each replication to serve as sources of infestation.

Result: Results showed that yam tubers treated with lemon peel extracts recorded relatively low mealy bug counts compared to untreated ones and, tubers treated with lemon extracts recorded relatively higher weights compared to those without any treatment. Furthermore, there were no significant differences in neither counted mealy bugs nor yam weight per treatment between extracts from leaves or peels. Lemon extract treatments did not affect sprouting and shelf life of tubers in storage. We conclude that lemon extracts are effective repellents of mealy bugs and can be promoted as a safe bio pesticide for stored yam against mealy bug infestation.

Key words: Extract, Lemon, Mealy bug, Tuber, Yam.

INTRODUCTION

Yam (*Dioscorea* spp.) is a root tuber crop mainly produced in Central and West Africa. Yam production is one of the main farming activities especially in the drier parts of Africa *e.g.*, Sudan savannah zone of Ghana (Reynolds *et al*., 2015; Khoury *et al*., 2016). They are important household staples which also serve as a source of income (Reynolds *et al*., 2015, Tchabi *et al*., 2016). The highest production of yam occurs in Central and West Africa. *Dioscorea alata* L. and *D. rotundata* Poir are the two dominant yam species cultivated in this sub-region (Orkwor and Adeniji, 1998). It is estimated that yam supplies a high per cent of the carbohydrate needs of people in Ghana and is also a source of income for a large section of the population (Wie *et al*., 2017).

Despite these enormous benefits, the production of yam is beset with major problems such as low soil fertility, high cost of production, high incidence of pests and diseases, poor post-harvest preservation *etc*. Increasing pressure from a range of insect pests (*e.g.*, leaf and tuber beetles, mealy bugs, scales insects), fungi (anthracnose, leaf spot, leaf blight, tuber rots) and viruses, as well as nematodes, contribute to sub-optimal yields and the deterioration of tuber quality in storage (Manyong and Oyewole, 1997). Mealy bugs are among the most destructive insect pests which attack yam tubers especially those in storage.

Mealy bugs are sap feeding insects with winged males and females possessing soft bodies with powdery coat. Young and older mealy bugs cluster in protective wax powder coating in leaf axis, neck of bulbs and spines. Mealy bugs attack a wide variety of crops including yams, citrus, cotton, pineapple, mango and sugarcane. Two species of mealy bugs, *Aspidiella hartii* and *Planococcus dioscorea* are very common on yams especially *D. cayenensis* and *D. alata*. Mealy bugs attack result in white looking colonies, which can cover the whole tuber. They also suck juices out of the yam tuber leading to weight loss and a reduction in quality and market value. The damage also reduces sprouting capacity when used as seed (Sauphanor *et al*., 1985; FAO, 1998).

The most common form of pest control in stored yams especially on insects is the use of synthetic pesticides that has been associated with problems of resistance, left over residues in food substances and environmental contamination (Hill, 1983). To solve some of the problems that come with the use of synthetic pesticides, essential plant oil extracts have been introduced in recent years as a better management option (Shobharani and Nandihalli, 2010; Tandon and Srivastava, 2018). This is because these plant oil extracts are considered environmentally safe with a rare,

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recorded resistance or left-over residues in food substances (Nerio *et al*., 2010). Plant essential oils are known to exhibit biological activities against wide spectrum of plant pests and may also act as fumigants, contact insect repellents and antifeedants. They can also affect growth, reproduction and insect behavior (Kimbaris *et al*., 2010 Koutsaviti *et al*., 2018). For example, the major citrus fruit essential oil constituent, limonene has high repellent effect on some insect species (Lota *et al*., 2002; Hollingsworth, 2005). Limonene has been reported to be a safe natural pesticide for the control of insect pests including mealy bugs (Hollingsworth, 2005). Botanical insecticides, including plant essential oils, are generally considered potential alternatives to synthetic insecticides (Isman, 2006), but few data exist on their effect on mealy bugs. For instance, Cloyd and Chiasson (2014) and Cloyd *et al*. (2009) evaluated the toxic effects of some commercially available plant products, including essential oils with positive results. In these experiments, essential oils and pectin from lemon peel were used to control insect pests. Hollingsworth (2005) found a high insecticidal effect of limonene, the major constituent of citrus fruit essential oils, on some mealy bug species. Botanicals or plant insecticides, including lemon peel leave extracts are generally considered suitable alternatives to synthetic insecticides (Isman, 2006).

In this research we used lemon extracts as biopesticides in controlling mealy bugs infested stored yam. Lemon and its extracts are readily available and cheap to obtain, hence the production of biopesticides from them in large quantities and a possible large-scale use in pest management activities can potentially cut down cost of mealy bugs management in addition to little or no environmental contamination compared to chemical control methods. Our hypothesis for this study was that lemon extracts has high repellent activity against mealy bugs infestation. As such the application of the lemon extracts will significantly reduce mealy bugs infestation in relation to synthetic pesticides on stored yams. We also hypothesized that, lemon extracts have other anti-sprouting activities on yams and hence retards sprouting.

MATERIALS AND METHODS

Study area

The experiment was conducted in a yam barn at Nyankpala campus of University for Development Studies. Nyankpala is in the Tolon District of the Northern region of Ghana. It is geographically located at latitude 9° 25′41″ N and longitude 0° 58′42″ W. It lies on altitude 183 above sea level (SARI, 2004).

Extraction from lemon peels and leaves

Disease-free ripe lemon peels and leaves were obtained from a lemon (*Citrus limonum*. L), washed thoroughly, cut into about 2cm pieces in length and sundried for about 16 hours. The sundried lemon peels and leaves were then finely grounded into powder. One hundred grams of the powdered peels and leaves each were placed into a 1 litre conical flask. Five-hundred milliliter of ether was added to each of the dried 100 g powdered peels and leaves and covered. The flask was shaken vigorously for 5 minutes and then allowed to stand overnight in a cool dry place under controlled temperature of 28°C and a relative humidity of 80%. Each of the mixtures were diluted with 250ml of water and allowed to stand for an hour the next day. The peel and leave extracts then settled at the top of each corresponding mixture and later decanted from the rest of the other unwanted sediments beneath it. The solvent was carefully transferred into a 1 liter conical flask and further diluted with 250 ml of water. The solvent extract contained in the flask was then placed in a water bath at 60°C. This was done to separate and evaporate ether in the mixture used for the extraction leaving water and the lemon extracts.

Application of treatments to yam tubers

Treatments for the experiment consisted of extracts of lemon peels, lemon leaves and distilled water (control). Treatments were rubbed on yam tubers using spongy cloths after they were thoroughly washed. Spongy cloths were dipped into the different treatments and then applied on each corresponding yam tuber. Using completely randomized design the treated tubers were arranged on shelves in a yam barn. Each treatment was replicated three times with ten tubers in each. Mealy bug infested yams were placed at the edges of each replication to serve as a source of infestation.

Data collection and analysis

Data were collected for a period of fifteen weeks on mealy bug number on the tubers, tuber weight loss and number of sprouted and rotten tubers. The length of the sprouts on tubers was also measured. Counted data were square root transformed and back transformed. The data were subjected to analysis of variance using Genstat Discovery Edition Four and treatment means compared using least significant difference (LSD) at 5% probability.

RESULTS AND DISCUSSION

Effect of lemon extracts on mealy bug abundance on yam tubers

The lemon extracts significantly influenced the number of mealy bugs recorded on yam tubers ($P<0.01$). Yams treated with lemon extracts recorded significantly low mealy bug infestation ($P<0.01$). Although treated yams recorded the least abundance of mealy bugs, increasing the duration of the experiment increased the number of recorded mealy bugs recorded (Fig 1).

Effect of lemon extracts on yam tuber weight

Yam tuber weight was significantly affected by lemon extracts ($P<0.01$). However, treatment was independent of the length of time the experiment was undertaken ($P=1.00$). The control recorded the least tuber weight compared to lemon extracts treatments. There was no significant difference between yam tuber weights treated with extracts from peel and leafs (Fig 2).

Effect of lemon extracts on number of sprouted tubers

Our results also showed that, the number of sprouted yam tubers was not significantly influenced by treatments (P=0.32). Though not significant, lemon extract treated tubers had more sprouts compared to the control. There was, however, a significant difference in the number of tubers that sprouted per week, more sprouting occurred towards 138 the end of the study period. The duration of treatment, however, did not significantly affect sprouting (P=0.99) (Fig 3).

Effect of lemon extracts on number of rotten tubers

The lemon extracts did not have significant effect on the number of rotten tubers (P=0.81). The lemon extracts and the control recorded similar values from 1 to 15 weeks of application. The interaction between treatment

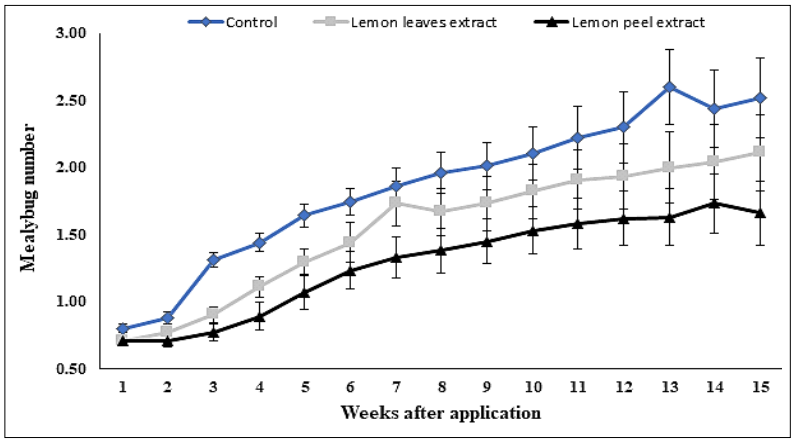

Fig 1: Influence of the lemon extracts on mealy bug population. Error bars represent the standard error of means.

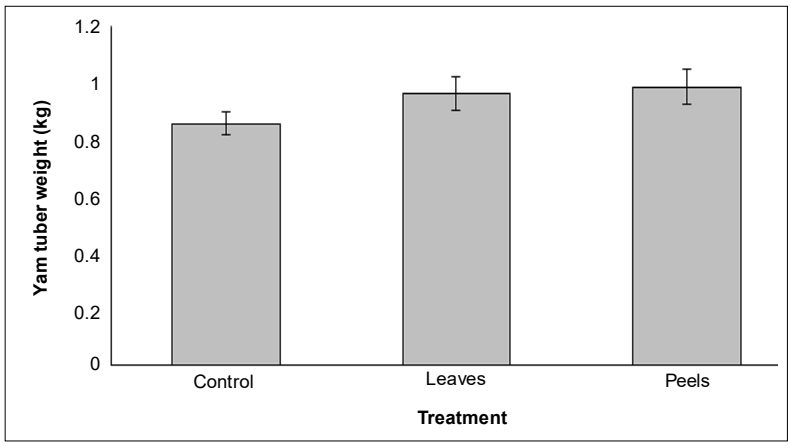

Fig 2: Effect of lemon extracts on yam tuber weight 15 weeks after treatment. Error bars represent the standard error of means.

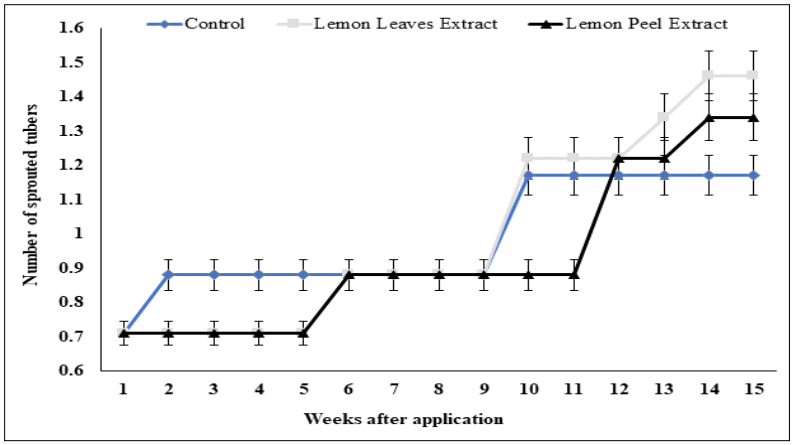

Fig 3: Effects of the lemon extract on the number of sprouted tubers. Error bars represent standard error of means.

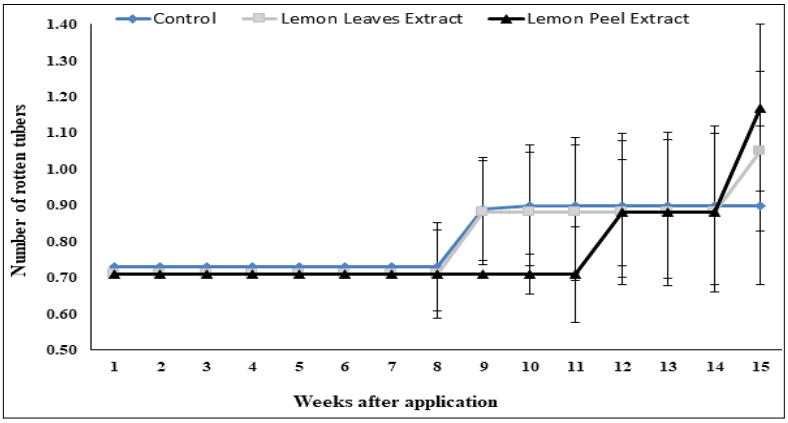

Fig 4: Effect of the lemon extracts on the number of rotten tubers. Error bars represent the standard error of means.

types and duration were also not significant (P = 0.98) (Fig 4).

Effect of lemon extracts on mealy bug numbers on yams and weight of tubers

Botanical insecticides, including plant essentials, such as lemon extracts are generally considered potential alternatives to synthetic insecticides (Isman, 2006). Our study revealed that lemon extracts achieved high repellent effect against mealy bugs. Lemon peel extracts achieved greater repellent effect compared to lemon leaf extracts although not very significant. This may be because of a higher concentration of limonene in the lemon peel extracts compared to the leaf extract.

This agrees with findings from Hollingsworth (2005), who examined the efficacy of limonene on mealy bugs. Unlike our experiment, he conducted a test by dipping mealy bugs into limonene liquid extracts. In this dip test, the soaked mealy bugs were killed. The main emphasis on this study was on repelling mealy bugs. His study confirmed that limonene is an effective natural alternative that can be used to kill wax covered insects such as mealy bugs. Limonene is also known to be environmentally safe natural pesticide for insect pests including mealy bugs (Hollingsworth, 2005). This study further reveals that yams treated with lemon extracts did not lose much weight compared to the control. The oil in the extract especially from the peels might have increased the shelf life of the treated yams especially from other diseases associated with mealy bug infestation as reported in other studies (Dalvadi *et al*., 2018). Another possible reason could have been the slowing of transpirational losses in the tubers treated with extracts. The loss of water by transpiration and respiration is a major cause of losses in yams. This conforms to an earlier publication by Osunde (2008) who did research on minimizing postharvest losses in yams and reported that physiological factors play a role in determining the storage quality. He further confirmed that the loss of water by transpiration and respiration in yams is an important factor which leads to loss of tuber weight.

Effect of lemon extract on storage duration and the number of sprouted tubers

The lemon extracts did not have any effect on preventing yam tubers from decaying. This suggests that the extracts did not exhibit antimicrobial activity against yam rot microbes. Limonene contained in lemon has been reported to have fungicidal and bactericidal properties (Jo *et al*., 2004; Singh *et al*., 2010. Bendaha *et al*., 2016; Chhikara *et al*., 2018). They are usually used as topical but, in this case, microbes that cause rot in yams are found within the tubers and that may explain why they were not useful in controlling rot in yam tubers.

The lemon extracts did not affect sprouting abilities of yam tubers. However, sprouting increased with duration of the experiment. Most of the sprouts occurred after the ninth week and by the end of the experiment in 15 weeks of treatment, sprouting increased by 100 folds. This period may coincide with the breaking of dormancy in yam. Dormancy is the physiological rest period of yam tubers without obvious external signs of physiological or biochemical activity that suppresses sprouting (Hamadina, 2011). The increase in sprouting towards the end of the study agrees with IITA (IITA, 1971) that reported that the appearance of sprouts on a matured yam tuber is evidence of release of dormancy.

CONCLUSION

We conclude from this experiment that lemon extracts significantly controlled mealy bug infestation on yam tubers. Additionally, lemon extract treatments helped reduce weight loss in yam tubers. However, the extract did not have any effect on sprouting of yam tubers neither did it protect the tubers against decay. It is recommended that to repel mealy bugs yam tubers should be rubbed with lemon peel extract before storage.

Conflict of interest: None.

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