STUDY ON THE MANAGEMENT OF SWEET POTATO WEEVIL (*Cylas puncticollis* (Boheman)) IN UMUAHIA, ABIA STATE.

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SUMMARY

Sweet potato weevil (Cylas puncticollis (Boheman)) infestation results in losses of millions of dollars annually. To protect crops in modern agriculture, integrated pest management can be a good alternative to synthetic insecticides. A field study was conducted in July to November 2018 on two orange-fleshed sweet potato varieties; Umuspo-1 and Umuspo-3 to study the management of sweet potato weevils. Two experiments: (i) Mulching with three plant leaves of Tephrosia vogelii, Alchornea cordifolia and Ageratum conyzoides and (ii) Earthing-up three levels (once, twice and thrice) were conducted. The experiments were laid out in randomized complete block design with three replicates. Parameters evaluated were, weevil population density, percentage colonization, root yield (marketable and unmarketable), yield-loss, percentage damaged roots and percentage control. Generally, control plots recorded higher weevil colonization, yield-loss, unmarketable and damaged roots. High significant ($P \leq 0.05$) crop yield was found on plots mulched with T.vogelii (7.15t/ha), A.cordifolia (5.37t/ha) and A.conyzoides (5.79t/ha) than earthing-up thrice (3.53t/ha). Lower insect colonization occurred in plots mulched with T.vogelii (38.30%) and earthing-up thrice (45.0%). Results from these studies revealed the potential of mulching with insecticidal leaves and earthing-up thrice practices for effective management of sweet potato weevil. The botanicals used are common, ecofriendly, less hazardous, easily propagated and should be adopted by farmers to enhance sweet potato production in Nigeria.

Keywords: Orange-fleshed, Sweet potato, *Cylas puncticollis,* Integrated pest management, mulching, earthing-up.

SWEET POTATO is an important food security crop in many developing countries (Korada *et al*., 2010) and one of the five most important crops in 40 developing countries besides rice, wheat, maize, and cassava (Elameen *et al*., 2008). Nigeria is being ranked as the 4th largest producer of sweet potato in the world and the 3rd largest producer in Africa with a total production figure of 4,013,786 metric tons in 2017 representing 3.6 % of the world production figure for 2017 (FAOSTAT, 2017).

Orange-fleshed sweet potato is a rich source of Beta-carotene a precursor of bio-available vitamin A and has potential of combating Vitamin A deficiency among rural resource-constrained farmers in many developing countries (Jaarsveld *et al*., 2005; Low *et al*., 2007; Burri, 2011). In Nigeria, it is grown mainly for the enlarged storage roots, which are usually eaten fresh, boiled, fried or roasted and the leaves may also be used as forage for livestock, or eaten as a vegetable (CTA, 2013).

Cylas puncticollis is the major pest of sweet potato in tropical regions of Africa and widespread of this sweet potato weevil infestation results in losses of millions of dollars annually (Jackai *et al*., 2006). Orange-fleshed sweet potato production in Nigeria is still bedeviled with numerous challenges such as low yield, pests infest all plant part; roots, stems, foliage, flowers and seeds. The average yield of the crop is still within a very low range of 3.0 t/ha compared with average yield values of 15 – 30 t/ha obtainable from other sweet potato-producing nations of the world like

China (Odebode, 2004). Among the factors implicated for the low yield trend of the crop in Nigeria, is the annual recycling of vines heavily loaded with pests and diseases (such as virus disease) (Islam *et al*., 2002) and scarcity of quality seed vine materials (Sorense *et al*., 2009) have been identified as the greatest challenge.

Due to the severity of many insect pests affecting crops, many African farmers increasingly resort to frequent use of commercial synthetic insecticides (Abate and Ampofo, 1996). The use of synthetic pesticides is not a permanent solution as this can be disastrous to health, eliminate natural enemies of insect pest and expensive for most constrained farmers. This practice is increasingly criticized as unsustainable and difficult to incorporate into agro-ecological intensification programs aimed at developing sustainable agricultural practices and promoting ecosystem services (Bommarco *et al*., 2013; Tittonell and Giller, 2013).

Integrated pest management emphasizes on the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms (Sandler, 2010). Mulching materials were found to minimize soil cracking, conserve soil moisture and provide a physical barrier that reduced the entry of weevils to roots (Talekar, 1987). Earthing-up is control strategy approach of hilling up that works to prevent the entry of weevils into tuber and oviposition by female weevils, but this works best only when performed at the tuber formation stage (Faisal *et al*., 2009; *Worku et al., 2014*). Natural products from plants have been considered one of the most promising sources of biorational products with new modes of actions to manage phytophagous insects (Rattan, 2010).

The specific objectives of this study are to evaluate the effect of an integrated management method involving earthing up and mulching with leaves of some botanicals on occurrence of sweet potato weevil and yield of orange-fleshed sweet potatoes.

MATERIALS AND METHODS

Field experiment was conducted at research farm of the Forestry Research Institute of Nigeria, Okwuta Isieke Ibeku, Umuahia from August to November 2018.

Collection and preparation of plant leaves

Fresh leaves of *Tephrosia vogelii*, *Alchornea cordifolia* and *Ageratum conyzoides* were collected in Umuahia. Using sensitive weighing balance scale, 50g of each fresh plant leaf was weighed and used immediately as mulch on the base of sweet potato plant at 5 and 10 weeks after planting on designated mulch plots.

Table 1: Properties of three plant leaves used in the study.

Common name	Scientific name	Family	Part used	Main insecticidal component
Fish bean poison	*Tephrosia vogelii*	Fabaceae	Leaves	Rotinone
Christmas bush	*Alchornea cordifolia*	Euphorbiaceae	Leaves	Octadecenoic acid
Goat weed	*Ageratum conyzoides*	Asteraceae	Leaves	Precocenes

Sweet potato varieties

The two cultivars of orange fleshed sweet potato vine cuttings are varieties of Umuspo-1 and Umuspo-3 which were purchased from the germplasm of National Root Crop Research Institute, Umudike. Umuspo -1 which is known as King J is semi-erect plant with thick vine and very vigorous growth of dark green palm shaped leaves. One of its outstanding characteristics is that it is resistant to Sweet potato virus disease (SPVD), and tolerant to *Cylas* spp. Umuspo-3 is a deep orange fleshed variety known as Mother's Delight, has a distinctive characteristic of an appetizing egg yolk deep orange flesh colour which indicated high vitamin A content, with purple creeping vine, heart shape leaf (Nwankwo *et al*., 2019).

Two experiments were conducted as follows. The first experiment was conducted to determine the effect of mulching on sweet potatoes weevil on orange-fleshed sweet potato cultivars. Experimental plots measuring 3 m in length × 2 m in width were divided into 2 ridges with 1m boarder between plots. Sweet potato was planted at a spacing of 0.3 m between stands and 1m between ridges. The treatments were 2 varieties of orange-fleshed sweet potato × 3 plant leaves factorial experiment laid out in a Randomized Complete Block Design (RCBD) and replicated three times. Fresh leaves of botanicals were collected, rinsed, weighed (50g per plant) and used as mulch. The second experiment was conducted to determine the effect of earthing up on sweet the population of potato weevil on orange-fleshed sweet potato cultivars. This experiment with 2 orange-fleshed sweet potato varieties × 3 levels of earthing up was a factorial design laid out in Randomized Complete Block Design (RCBD) with three replications. Earthing up was done manually by hilling up soil to a height of 30 cm from ground level to the base of sweet potato plant once at 4 weeks, twice at 4 and 8weeks and thrice at 4, 8 and 12 weeks after planting. The same plot size was maintained as in experiment 1, while spacing between experiments was 2 m.

Fertilizer (NPK 15:15:15) was applied at the rate of 400 kg/ha by band placement at 4 weeks after planting (WAP). Weeding was done manually at 4 WAP, roguing at 8 and 12 WAP and harvesting of sweet potatoes was done manually at 4 months after planting.

Data collection

Percentage colonization was determined by direct visual counting of adult *Cylas puncticollis* from ten randomly selected plants at 6, 8,10 and 12 WAP, and the total percentage colonization was calculated (Mtunda *et al*., 2001) as follows:

$$\text{Percentage Colonization} = \frac{\text{Number of sampled plants infested or colonized per plot}}{\text{Total number of sampled plants per plot.}} \times \frac{100}{1}$$

Number and weight of total sweet potato roots per plot at harvest was determined by counting the total number of the storable roots harvested per plot and weighing them using Camry 20 kg weighing scale. Harvested roots were also, separated depending on the size and healthiness of the root into marketable (healthy) roots when the weight of the root is greater or equal to 100 g and is healthy, and unmarketable (infested) roots when the weight of the root was less than 100 g and roots were visually infested by *C. punticollis* (Mtunda *et al*., 2001). Similarly, the percentage damaged (infested) roots at harvest per plot was calculated thus:

$$\text{Percentage damaged roots} = \frac{\text{Number of infested roots per plot}}{\text{Total number of harvested roots per plot}} \times 100$$

In the control plots, roots infested with sweet potato weevils were separated from the total number of roots harvested per control plot and the data produced were used to generate percentage damage control which is equivalent to the percentage damaged roots at harvest per treated plot and it was calculated as follows:

Percentage control = $\frac{\text{Percentage damage of control} - \text{Percentage damage of treatment}}{\text{Percentage damage of control}} \times 100$ (Ehisianya *et al*., 2013)

The yield loss was calculated using the formula:

Yield loss = $\frac{\text{Total root weight} - \text{Healthy root weight}}{\text{Total root weight}} \times 100$ (Kabir *et al*., 2001<u>1</u>5)

The yield of storable root was determined by counting and weighing (Camry 20-kilogram scale) the harvested roots, and expressing it in tons per hectare using the formula below:

Storable root yield (t/ha) = $\frac{\text{Yield (kg)/ Plot}}{\text{Plot area (m2)}} \times \frac{1000}{100}$ (Nwankwo *et al*., 2019)

All data collected were subjected to analysis of variance (ANOVA) using GENSTAT (2007). Significant means (P≤0.05) were separated using Fishers Protected Least Significant Differences (LSD) at 5 % level of significance.

RESULTS

Results presented in Table 2 indicate that there was a high significant difference (P ≤ 0.05) of the number of *Cylas puncticollis* population density between mulched plots and earthing up plots. Lower number of insect pest population density was recorded in plots with *T.vogelii* mulch (13.72) followed progressively, by plots where earthing up was done thrice (16.78), mulched with *A. conyzoides* (16.78), *A. cordifolia* (17.34) and earthing up twice (18.73) at 12 WAP, respectively. However, the population density of *Cylas puncticollis* was significantly higher in Umuspo-1 variety of orange-fleshed sweet potato than Umuspo-3 variety for the duration of both experiments.

In Fig. 1, lower insect pest percentage colonization was recorded in mulched plot of *T.vogelii* (38.30%) at 12 WAP followed by plots earthing up thrice (45%) at 12 WAP (Fig. 2), which were highly significantly different (P≤0.05) from other practices, whereas highest percentage colonization generally, occurred in the untreated control plots.

In Table 3, there was significant (P≤0.05) difference in root yield attributes between the sweet potato varieties, with Umuspo-3 giving higher root yield of 6.93 t/ha in mulched plots and 4.40 t/ha in earthing up plots than Umuspo-1, compared to the untreated (control) plots of both varieties gave the least root yield in the two experiments. Consequently, between the sweet potato varieties, Umuspo-3 recorded higher number of marketable roots in mulched plots (52.43kg) and earthing up plots (26.11kg) than Umuspo-1 mulched plots (37.32kg) and earthing up plots (15.18kg) whereas the untreated (control) plots of both varieties gave the least number of marketable roots in the two experiments. However, all mulched plots significantly (P≤0.05) recorded more marketable roots (kg) per plot and yield (t/ha) than the untreated (control). Plots mulched with *T.vogelii* had the highest yield (7.15 t/ha) followed by mulched plots with *A.conyzoides* (5.79 t/ha), *A.cordifolia* (5.37 t/ha) and earthing up thrice (3.53 t/ha).

Table 2: Population density of *Cylas puncticolis* on mulched and earthing up plots

Treatment	Mulched plots				Earthing up plots			
	6 WAP	8 WAP	10 WAP	12 WAP	6 WAP	8 WAP	10 WAP	12 WAP
Variety								
Umuspo-1	7.04	11.08	15.25	19.43	8.99	13.44	18.04	21.93
Umuspo-3	6.49	10.38	13.72	17.62	7.32	12.47	15.81	19.29
LSD (0.05)	NS	NS	NS	1.55	1.11	NS	2.07	2.49
Mulching material								
T. vogelii	4.54	7.88	10.66	13.72	NA	NA	NA	NA
A. cordifolia	5.65	8.99	13.72	17.34	NA	NA	NA	NA
A. conyzoides	5.65	8.71	12.61	16.78	NA	NA	NA	NA
Control	11.22	17.34	20.96	26.25	NA	NA	NA	NA
Mean	6.76	10.73	14.49	18.52	NA	NA	NA	NA
LSD (0.05)	2.45	2.48	2.35	2.19	NA	NA	NA	NA
Earthing up frequency								
Once	NA	NA	NA	NA	7.32	11.50	16.23	21.24
Twice	NA	NA	NA	NA	7.32	11.77	15.95	18.73
Thrice	NA	NA	NA	NA	7.88	11.77	15.11	16.78
Control	NA	NA	NA	NA	7.32	16.78	20.40	25.69
Mean	NA	NA	NA	NA	8.16	12.96	16.92	20.61
LSD (0.05)	NA	NA	NA	NA	1.56	2.72	2.92	3.52

NA = Not applicable; NS = Not significantly different; WAP = Weeks after planting

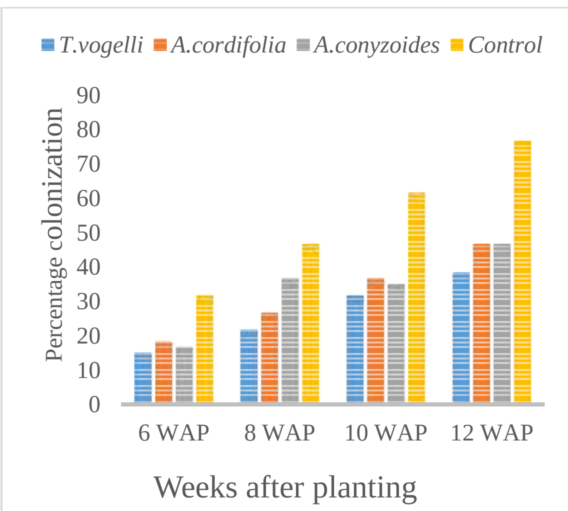

Figure 1: Percentage colonization on mulched plots *by Cylas puncticollis.*

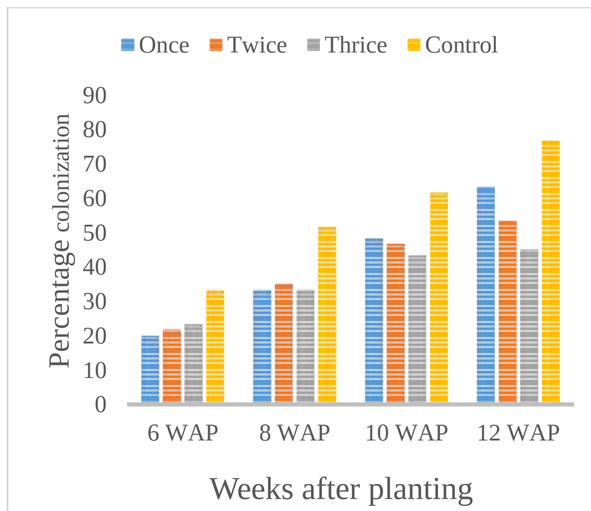

Figure 2: Percentage colonization on earthing up plots *by Cylas puncticollis*.

Also, significant difference (P≤0.05) was recorded in marketable roots per plot and yield in the earthing up practices than the control plot. Umuspo-3 orange-fleshed sweet potato variety significantly recorded higher yield, marketable and unmarketable roots than Umuspo-1 variety in both experiments.

Table 3: Yield, weight of marketable and unmarketable Sweet potato roots on mulched and earthing up plots.

Treatment	Mulched plots			Earthing up plots		
	Yield (t/ha)	Marketable roots (kg	Unmarketable roots (kg)	Yield (t/ha)	Marketable roots (kg)	Unmarketable roots (kg)
Variety						
Umuspo-1	3.62	37.32	1.53	1.92	15.18	0.92
Umuspo-3	6.93	52.43	7.54	4.40	26.11	3.98
LSD (0.05)	0.98	7.73	2.69	0.39	2.22	1.03
Mulching material						
T. vogelii	7.15	60.57	2.93	NA	NA	NA
A. cordifolia	5.37	45.23	2.93	NA	NA	NA
A. conyzoides	5.79	45.69	3.39	NA	NA	NA
Control	2.78	28.03	8.51	NA	NA	NA
Mean	5.27	44.88	4.44	NA	NA	NA
LSD (0.05)	1.39	10.94	3.80	NA	NA	NA
Earthing up frequency						
Once	NA	NA	NA	3.03	19.85	2.59
Twice	NA	NA	NA	3.26	22.91	1.48
Thrice	NA	NA	NA	3.53	25.69	0.08
Control	NA	NA	NA	2.81	15.39	5.65
Mean	NA	NA	NA	3.16	20.96	2.45
LSD (0.05)	NA	NA	NA	0.55	3.14	1.45

NA = Not applicable

In Table 4, Umuspo-1 Sweet potato was significantly (P≤0.05) higher than Umuspo-3 variety with respect to percentage infestation, damage and yield loss. Significantly (P≤0.05), high percentage damaged root and yield loss was recorded in untreated plots of both Umuspo-1 (5.46%; 9.03%) and Umuspo-3 (13.73%;14.48%) varieties, respectively. Earthing up thrice significantly (P≤0.05) recorded lower percentage damaged roots (24.20%) and yield loss (26.46%) over untreated control and other earthing up practices. A significantly lower percentage of root damage and yield loss was observed in earthing up thrice (0.05; 0.05%) and mulched plots with *T.vogelii* (4.54%; 4.31%), *A.cordifolia* (4.91%; 5.71%) and *A.conyzoides* (5.72%; 7.39%) respectively.

There were significant (P≤0.05) differences in effective percentage control which was indicated in earthing up thrice (99.8%), with mulched plots of *A.cordifolia* (80.5%), *A.conyzoides* (78.17%), *T.vogelii* (77.7%) and earthing-up twice (75.7%), respectively. However, Umusop-3 orange-fleshed sweet potato variety significantly (P≤0.05) recorded higher percentage root damage and yield loss than Umuspo-1 in the two experiments studied.

Table 4: Percentage root damaged and yield loss caused by *Cylas puncticollis* infestation of Sweet potato on mulched and earthing up plots.

Treatment	Mulched plots			Earthing up plots		
	Damaged roots	Yield loss	Control	Damaged roots	Yield loss	Control
Variety						
Umuspo-1	4.37	5.96	65.50	5.46	9.03	60.40
Umuspo-3	13.73	14.48	52.70	13.82	11.82	58.20
LSD (0.05)	4.76	4.31	NS	4.37	5.37	19.93
Mulching material						
T. vogelii	4.54	4.31	77.70	NA	NA	NA
A. cordifolia	4.91	5.71	80.50	NA	NA	NA
A. conyzoides	5.72	7.39	78.10	NA	NA	NA
Control	21.02	23.48	0.00	NA	NA	NA
Mean	9.05	10.22	59.10	NA	NA	NA
LSD (0.05)	6.73	6.09	25.23	NA	NA	NA
Earthing up frequency						
Once	NA	NA	NA	9.19	9.78	61.60
Twice	NA	NA	NA	5.11	5.40	75.70
Thrice	NA	NA	NA	0.05	0.05	99.80
Control	NA	NA	NA	24.22	26.46	0.00
Mean	NA	NA	NA	9.64	10. 42	59.30
LSD (0.05)	NA	NA	NA	6.18	7.59	28.19

NA = Not applicable; NS – Not significantly different

DISCUSSION

Sweet potato weevils are widely dispersed in tropical regions of the world and their management is the key issue faced by sweet potato farmers in Nigeria. In this study, the lower number of weevil population density recorded in *T.vogelii* mulched plot was due to insecticidal property of the plant. This report is in line with some previous observation reported, that the particle size of plant extracts powders influenced insecticidal actions (Emearsor *et al*., 2005) and also the plant parts, oil, extracts, and powder mixed with grain reduced insect oviposition, egg hatchability, postembryonic, and progeny development (Asawalam and Adesiyan, 2001). This is also the reason of lower insect pest percentage colonization recorded in mulched plot of *T.vogelii* (31.70% at 12 WAP). The effect of *T.vogelii* leaves on reduced insect colonization and population density could be due to higher presence of rotenoids in the leaves, corresponding with earlier findings that the biological activity of the plant was due to foliar rotenoids (Belmain *et al*., 2012).

Earthing up thrice which recorded lower percentage damaged roots (24.20%), yield loss (26.46%) and effective percentage control over other earthing up practices, conforms with previous work (Odebode, 2004) on three times earthing-up and prompt harvesting which reduced the number of tuber damage per plot because hilling up prevented soil cracking that helps to hinder adult weevil movement to reach the tubers underground for egg laying and subsequent damage by larvae. Earthing up thrice also recorded higher number of marketable roots. This finding is in line with the significant report (Faisal *et al*., 2009) on the highest yield of both the corm and cormels when primary corms were planted and earthing-up was done three months after planting.

High effective sweet potato weevil control which was indicated with mulched plots of *A.cordifolia* (80.5%) agrees with a research report that azadirachtin (*Azadirachta indica*), rotenone and it relatives (*Tephrosia vogelii*) are among some of the commercially important plant-derived efficacious metabolites used in modern pest control programs (Kanchanapoon, 2002). In *Ageratum cornyzoides* the terpenic compounds, mainly precocenes, with their antijuvenile hormonal activity are probably responsible for the insecticide effects (Ming, 1999).

More yield and marketable roots recorded in mulched plots was probably due to replenished soil nutrient which enhanced soil fertility. This result agrees with the report that plant materials such as *Alchornea cordifolia* leaves plays substantial role in improving soil nutrient status and fertility (Talekar, 1987). Orange-fleshed sweet potato yield in mulched plots; *T.vogelii* had highest yield (7.15 t/ha) followed by mulched plots with *A.conyzoides* (5.79 t/ha), then *A.cordifolia* (5.37 t/ha) and earthing-up thrice (3.53 t/ha) surpassed the average yield of sweet potato 3t/ha produced in Nigeria 2017 (Odebode, 2004).

In this study Umuspo-3 orange-fleshed sweet potato variety significantly had higher unmarketable root and percentage root damage. However, Umuspo-3 variety yield (t/ha) and marketable roots (kg) were higher. Perhaps the thick pink covering of Umuspo-1 orange-fleshed sweet potato variety had effect in preventing weevil penetration and or posses' difficulty for progeny root development unlike the soft orange covering of Umuspo-3 orange-fleshed sweet potato variety, although Umuspo-3 produced higher root yield. Finding conforms to result from previous investigation, suggested that root size, shape, hardness and arrangement might play an important role in conferring weevil resistance in the field (Talekar, 1987).

CONCLUSION

This study revealed that the integration of earthing-up and mulching with botanical leaves significantly lowered *C.puncticollis* infestation and damage of sweet potato roots. Based on this finding, the use of plant leaves of insecticidal potential as mulch significantly reduced weevil infestation on sweet potato root at harvest. These botanicals served as weevil repellants, anti-juvenile hormonal activity and replenished soil nutrient, resulting to increased yield and more marketable sweet potato roots. Also botanicals exhibited high yield and marketable roots, less hazardous, eco-friendlier and was effective in reducing sweet potato weevil infestation; *C.puncticollis* damage. Earthing up thrice significantly recorded the least percentage damaged roots, yield loss and higher percentage control than other earthing-up practices, thus should be adopted. Umuspo-3 orange-fleshed sweet potato containing high beta-carotene is high yielding and should be promoted. Further studies should be conducted on mulching with these phytochemical plant materials and earthing-up thrice as integrated management practices and should be adopted by farmers, to increase sweet potato production in Nigeria.

REFERENCES

Abate, T. and Ampofo, J. K. 1996. Insect pests of beans in Africa: their ecology and management. *Annual Review Entomology*, 41: 45 - 73.

Asawalam, E.F. and Adesiyan, S. 2001. Potential of *Ocimum basilicum* (Linn) for the control of maize weevil *Sitophilus zeamais* (Motsch). *Nigeria Agricultural Journal*, 32(1): 195–201.

Belmain, S. R., Amoah, B. A., Nyirenda, S. P., Kamanula, J. F. and Stevenson, P. C. 2012. Highly variable insect control efficacy of *Tephrosia vogelii* chemotypes. *Journal of Agricultural and Food Chemistry*, 60(40): 10055 – 10068.

Bommarco, R., Kleijn, D. and Potts, S. G. 2013. Ecological intensification: harnessing ecosystem services for food security. *Trends Ecology Evolution*.;28: 230 - 238.

Burri, B. J. 2011. Evaluating sweet potato as an intervention food to prevent vitamin A deficiency. *Comprehensive Reviews in Food Sciences Food Safety*; 10:118 - 130.

CTA 2013. Agrodok, 28. CTA P.O. Box 6700AJ, Wageningen. The Netherlands; Pp. 35 - 37.

Ehisianya, C.N., Ukeh, D., Isah, M., Lale, N. and Umeozor, O. 2013. Field Efficacy of Neem Seed Oil and Diazinon in the Management of Sweet potato Weevil, *Cylas punticollis* (Boheman) in South-eastern Nigeria. *National Root Crops Research Institute, Umudike,* Nigeria, 2: 1

Elameen, S., Fjellheim, A. and Larsen, 2008. Analysis of genetic diversity in a sweetpotato (*Ipomoea batatas* L.) germplasm collection from Tanzania as revealed by AFLP. *Genetic Resources and Crop Evolution,* 55(3): 397 - 408.

Emearsor, K. C., Ogbuji, R. O. and Emosairue, S. O. 2005. Insecticidal activity of some seed powder against *Callosobruchus maculatus* (F) (Coleoptera: Bruchidae) on stored cowpea. *Journal of plant disease and protection*, 112(1): 80 - 87.

Faisal, S. M., Salam, M. A., Islam, M. S. and Hossain, M. I. 2009. Effects of Planting Material and Earthing-Up on Yield and Yield Contributing Attributes Of MukhiKachu, Bangladesh. *Journal of Agricultural Resources*, 34(2): 263-267.

FAOSTAT. 2017. farmer groups in Uganda to develop new sweet potato cultivars: decentralization and building on traditional approaches. Euphytica; 159: 217–228.

Islam, M. J., Haque, M. Z., Majunder, U. K., Haque, M. M. and Hossain, M. F. 2002. Growth and yield potentials of nine genotypes of sweet potato. *Pakistan Journal of Biological Science,* 5(5): 537- 538.

Jaarsveld, P. J., Faber, M., Tanumihardjo, S. A., Nestel, P., Lombard, C. J. and Benadé, A. J. S. 2005. β-carotene–rich, orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose–response test1,2,3. *American Journal of Clinical Nutrition* 81:1080–1087.

Jackai, L. E., Sosinski, B. and Jackson, D. M. 2006. Occurrence and intra-specific variation of sweet potato weevil (Brentidae: Coleoptera) in relation to its potential spread in southern United States of America and the Caribbean, *in* ISHS Acta Horticulturae 703: II International Symposium on Sweet potato and Cassava: Innovative Technologies for Commercialization. *International Society for Horticultural Science, Leuven, Belgium.* Pp 197–204.

Kabir, S. M. W., Ogenga-Latigo, N. E. J. M., Smit, T. E. S. and Rees, D. 2001. Influence of Sweet potato rooting characteristics on infestation and damage of *Cylas spp. African Crop Science, Journal,* 9: 165-174.

Kanchanapoon, D. 2002. Chemical composition of *Schoenocaulon officinale*. www.cpb.pharm.org.jp/cpb/.../c06-0863.pdf..., Accessed July 23, 2015.

Korada, R. R., Nasakar, S. K., Palaniswami, M. S. and Ray, R. C. 2010. Management of sweet potato weevil *Cylas formicarius* (Fab.): An overview. *Journal of Root Crops*, 36: 14-26.

Low, J. W., Arimond, M., Osman, N., Cunguara, B., Zano, F. and Tschirley, D. 2007. A food-based approach: introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *Journal of Nutrition,* 137(5):1320 - 1327.

Ming, L.C. 1999. *Ageratum conyzoides*: A tropical source of medicinal and agricultural products. *In Janick, J. (ed.).* Perspectives on new crops and new uses. *Alexandria VA: ASHS Press.469 - 473.*

Mtunda, K. D., Chilosa, D., Rwiza, E. U., Kilima, M. and Kiozya, H. 2001. Damage shelf-life of sweet potato during marketing. *African Journal of Crop Science,* 9: 301 - 307.

Nwankwo, I. I. M., Ikoro, A.I., Akinbo, O.K., Okeagu, O.D. and Korieocha, J. N. 2019. History Development and Impact of Orange Fleshed Sweet Potato Varieties in Nigeria Since 2012 -A Review. *International Journal of Agricultural Research, Sustainability and Food Sufficiency* (IJARSFS), 6(04): 386 - 401.

Odebode, S. O. 2004. Acceptability of Sweet potato "sparri" and its potentials for enhancing food security

Rattan, R. S. 2010. Mechanism of action of insecticidal secondary metabolites of plant origin. *Crop Protection*, 29(9): 913 - 920.

Sandler, H. A. 2010. Integrated Pest Management". *Cranberry Station Best Management Practices*. **1** (1): 12 - 15.

Sorense, K. A. 2009. Sweet potato insects. Identification, biology and management.

Talekar, N. S. 1987. Influence of cultural pest management techniques on the infestation of sweet potato weevil. *International Journal of Tropical Insect Science,* 8: 809 - 814.

Tittonell, P. and Giller, K. E. 2013. When yield gaps are poverty traps: The paradigm of ecological intensification in African small holder Agriculture. *Field Crop Research*, 143: 76–90.

Worku, **W., Emana, G. and Waktole, S.** *2014***.** Integrated Management of Sweet potato Weevil (*Cylaspuncticollis* (B.)). Coleoptera: Curculionidae at Chano Dorga, Southern Ethiopia. *Asian Journal of Agricultural Research* 8(1):17-29.