ISSN 1996-3351

Asian Journal of Biological Sciences

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Asian Journal of Biological Sciences

ISSN 1996-3351
DOI: 10.3923/ajbs.2019.337.341

Research Article
Ecological Management of Sweetpotato Weevil, *Cylas puncticollis* (Boh.) (Coleoptera: Brentidae) Infesting Sweetpotato Varieties at Kuru, Plateau State, Nigeria

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Abstract

Background and Objective: African sweetpotato weevil, *Cylas puncticollis* (Boh.) inflict huge damage to sweetpotato thereby diminish its potential as security crop. This study was to determine the influence of varietal and cultural control tactics for the management of field infestation by *C. puncticollis*. **Materials and Methods:** The experiment was conducted at the Research Farm in the National Root Crops Research Institute (NRCRI), Kuru sub-station, (Latitude 09°44'N, Longitude 08°44'E and Altitude 1231.6 m above sea level), Plateau state Nigeria in 2008. The (6×3×3) factorial combinations were laid out in a Randomized Complete Block Design and replicated thrice. **Results:** Data were subjected to analysis of variance. Significant means were separated using Studentized Newman Keul's test ($p = 0.05$). Results indicated that significantly ($p \geq 0.05$) higher root yield were obtained from sweetpotato varieties TIS2532.op.1.13, followed by TIS87/0087 and the least was from TIS8164. The response of root to attributes of *C. puncticollis* followed similar trend with 52.74% infestation on TIS2532.op.1.13 and 39.45% on TIS8164 roots. Carotene-rich (var. CIP440293) had moderate yield and susceptibility to *C. puncticollis*. Sweetpotato roots harvested from mound and ridge methods of tillage had significantly higher yield than those from flat and had significantly higher attributes of *C. puncticollis*. The delay in the time of harvest from 4-6 months after planting (MAP) significantly increased score (2.00-4.28), number of adult (1.54-9.11) and damage (15.57-66.74%) of sweetpotato roots. **Conclusion:** The results underscore the potential of sweetpotato varieties especially var. CIP440293 and recommended planting on mounds and early harvesting for control of the *C. puncticollis* at Kuru, Nigeria.

Key words: *Cylas puncticollis*, infested roots, tillage methods, sweetpotato

Received: December 03, 2018 Accepted: February 01, 2019 Published: March 15, 2019

Citation: C.N. Ehisianya, 2019. Ecological management of sweetpotato weevil, *Cylas puncticollis* (Boh.) (Coleoptera: Brentidae) infesting sweetpotato varieties at Kuru, Plateau state, Nigeria. Asian J. Biol. Sci., 12: 337-341.

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Despite the importance of sweetpotato, *Ipomoea batatas* (Lam.) to a subsistence economy like Nigeria, growth in its output in the last three decades was accounted for by increase in land area than by increase in yield[1]. This low productivity could be attributed to sweetpotato weevil (*Cylas* spp.) attack[2,3] and the unavailability of improved varieties[4]. Losses due to sweetpotato weevil damage range[5] from 1-100%. The weevil damage varies from season to season and from location to location. The damage by weevil is higher during the dry season[6]. One of the reasons for the high level of infestation is the fact that the crop can be successfully grown throughout the year and infests all plant parts; roots, stems, foliage and flowers seeds[7].

Ecological management is an age-long tactics of solving insect problems in crop production. Cultural control is a key component of IPM and currently the most promoted strategy for subsistence sweetpotato production[8]. Tillage modifies soil texture, moisture, temperature and other characteristics in ways that either benefit or deter insect pest. Tillage must be based on knowledge of soil community ecology, as well as the acceptable limits of good agronomic practices. Conversely, avoiding tillage promotes crusting or compaction of soil surface and prevent gravid female *C. puncticollis* from penetrating soils for oviposition. Adopting ecological management approach can save cost of pesticide as well as the fuel, equipment and labour used to apply it.

The study attempts to provide information by ascertaining systematically, the tillage methods that can influence the infestation, development and damage by this weevil with a view of developing effective management, since no single control method provides adequate protection when the weevil population is high. The economically and environmentally benign options of integrating variety, cultural practices such as tillage method and time of harvest for management of this pest for small-scale sweetpotato farmers in the north central agro-ecology of Nigeria was therefore investigated.

MATERIALS AND METHODS

Experimental site: Field experiment was conducted at the Research Farms at the National Root Crops Research Institute (NRCRI), Kuru station (Latitude 09°44'N, Longitude 08°44'E and Altitude 1231.6 m above sea level), Plateau state, Nigeria to evaluate the effectiveness of variety, tillage method and time of harvesting sweetpotato for the control of *C. puncticollis*.

Experimental procedure: The treatments consisted of 6 elite sweetpotato varieties namely: TIS87/0087, Ex-Igbariam, TIS2532.op.1.13, TIS86/0356, TIS8164 and CIP440293, three tillage methods (mound, ridge and flat) and three harvest times (4, 5 and 6 months after planting, MAP). The ($6\times3\times3$) factorial combinations were laid out in a Randomized Complete Block Design and replicated thrice. Plot size was 2×3 m. Planting was done in August (i.e., minor planting season), 2008. Plant spacing was 0.3×1 m apart on ridge and flat, while it was three stands per mound in a triangular pattern below the tip of each mound of 35 cm high and 1 m apart. Fertilizer (NPK, 15:15:15) was applied at the rate of 400 kg ha^{-1} at 4 weeks after planting (WAP) by ring placement method, after manual weeding. Rouging was at 8 and 10 WAP.

Harvesting was done sequentially on a monthly basis of 4, 5 and 6 MAP. Roots were cleaned and sorted into infested and clean, counted and weighed. A root was considered infested if it had the characteristic dark scarred spot indicating weevil penetration and feeding.

Data collection and statistical analysis: The following data were recorded at harvest: Number and weight of total roots per plot, number and weight of marketable (>100 g root size) and unmarketable (<100 g root size) roots[9] per plot, percentage infestation (number of infested roots per plot divided by the number of total roots harvested per plot multiplied by 100), while percentage damage (weight of infested roots per plot divided by weight of total roots harvested per plot multiplied by 100) and severity of root damage per plot was assessed using a five-point score[10], where 1 = 0%; 2 = 1-25%; 3 = 26-50%; 4 = 51-75%; 5 = $\geq$75% and number of *C. puncticollis* (Boh.) adults and immature (pupae and larvae) in roots by dissecting infested roots with a sharp knife.

The number and weight of roots (ha^{-1}) at harvest were determined. Count data namely: *C. puncticollis* adult, immature and total progeny numbers were transformed to square root ($\sqrt{x}\pm0.5$) values, whereas data in percentage were transformed to arcsine values. This was to improve the normality of variable (variance stability) after which they were subjected to analysis of variance. Significant means were separated using Studentized Newman Keul's (SNK) test ($p = 0.05$).

RESULTS

Analysis of variance on results showed significant ($p\leq0.05$) difference among the sweetpotato varieties (Table 1). TIS2532.op.1.13 gave a significantly ($p\leq0.05$) higher

Table 1: Effect of variety and time of harvest on yield and *Cylas puncticollis* (Boh.) attributes of sweetpotato

	Sweetpotato variety					
Attributes	TIS87/0087	Ex-Igbariam	TIS2532.op.1.13	TIS86/0356	TIS8164	CIP440293
Root yield						
Total number	88765.00±2913.48[b]	71235.00±3163[c]	97531.00±3397.26[a]	62716.00±2250.79[d]	58272.00±2991.51[d]	60494.00±2660.88[d]
Total weight	21.69±1.38[b]	16.69±0.97[c]	24.63±1.42[a]	14.99±0.84[c]	14.94±1.02[c]	15.78±0.90[c]
Marketable number	39259.00±2486.64[a]	31235.00±1933.92[b]	43333.00±2486.64[a]	29012.00±1750.64[b]	29506.00±2234.32[b]	28272.00±2531.04[b]
Marketable weight	17.30±1.38[b]	13.27±1.01[c]	20.00±1.44[a]	12.10±0.86[c]	12.48±1.08[c]	13.00±0.87[c]
***Cylas puncticollis* (Boh.)**						
Score	3.44±0.23[b]	2.85±0.22[c]	3.82±0.21[a]	2.63±0.21[c]	2.70±0.21[c]	3.26±0.20[b]
Adult	5.93±0.71[b]	5.07±0.63[c]	7.01±0.78[a]	4.85±0.62[c]	4.75±0.59[c]	4.85±0.55[c]
Immature	13.48±1.23[b]	11.12±1.22[c]	14.84±1.27[a]	9.96±1.03[cd]	9.32±1.05[d]	11.12±1.02[c]
Infestation (%)	49.01±3.14[ab]	44.26±3.87b[c]	52.74±3.95[a]	39.66±3.51[c]	39.45±3.69[c]	47.55±3.26[b]
Damage (%)	44.45±4.39[a]	38.31±4.49[b]	48.12±4.78[a]	33.35±4.19[c]	33.42±3.94[c]	40.24±4.33[b]

Means within a row followed by the same letter do not differ significantly from each other (p>0.05, SAS, PROC GLM, SNK)

Table 2: Effect of tillage method on yield and *Cylas puncticollis* (Boh.) attributes of sweetpotato

	Tillage method		
Attributes	Mound	Ridge	Flat
Root yield			
Total number	76975.00±3045.2[a]	74568.00±2924.2[a]	67963.00±2831.3[b]
Total weight	19.12±0.88[a]	18.67±0.96[a]	16.57±0.89[b]
Marketable number	36605.00±1750.2[a]	33519.00±1736.6[a]	30135.00±1582.2[b]
Marketable weight	15.65±0.86[a]	15.06±0.92[ab]	13.36±0.85[b]
Cylas puncticollis			
Score	3.20 ±0.17[a]	3.28±0.17[a]	2.87±0.14[b]
Adult	5.73±0.52[a]	5.67±0.92[a]	4.83±0.39[b]
Immature	12.11±0.89[a]	12.17±0.85[a]	10.64±0.75[b]
Infestation (%)	47.08±2.77[a]	47.47±2.37[a]	41.73±2.55[b]
Damage (%)	40.60±3.24[a]	41.66±3.18[a]	36.68±2.95[b]

Means within a row followed by the same letter do not differ significantly from each other (p>0.05, SAS, PROC GLM, SNK)

total number (97531.00) and weight (24.63 t ha^{-1}) of roots when compared to the others varieties. Similarly, its marketable root number (43333.00) and weight (20.00 t ha^{-1}) were also significantly ($p \leq 0.05$) higher than others, except with the marketable root number of TIS87/0087 (39259.00). TIS8164 yielded the least with 14.94 t ha^{-1}. The *C. puncticollis* attributes on root namely: score, number of adult and immature stages, percentage infestation and damage on TIS2532.op.1.13 was significantly ($p \leq 0.05$) higher, followed by TIS87/0087, whereas TIS8164 gave the least (Table 1).

The effect of tillage method on yield and *C. puncticollis* attributes on sweet potato is presented in Table 2. Root yield from sweetpotato planted on mound and ridge were significantly ($p \leq 0.05$) higher than those planted on flat. Similarly, all attributes of *C. puncticollis* as a pest on roots were also significantly ($p \leq 0.05$) higher on mound and ridge than on flat.

Analysis of variance on result also showed that harvesting sweetpotato roots at 5 MAP gave a total (80432.00 and 21.53 t ha^{-1}) and marketable (40679.00 and 18.01 t ha^{-1}) root numbers and weights, which was significantly ($p \leq 0.05$) higher than roots from harvesting at 4 or 6 MAP (Table 3). Pest attributes of *C. puncticollis* on roots indicated consistent increase with time of harvest as percentage damaged roots at 4, 5 and 6 MAP was 15.57, 36.63 and 66.74%, respectively (Table 3).

DISCUSSION

Sweetpotato cultivars TIS2532.op.1.13 and TIS87/0087 performed better than others tested in terms of yield and thus corroborate the findings of Onunka[11] and Eke-Okoro[12] which concluded that they have potentials for high yields. Unfortunately, they were also the most susceptible to infestation and damage by *C. puncticollis* which confirms observations of Anioke and Ogbalu[4], that var. TIS2532.op.1.13 is the most susceptible. Results of earlier field trials had suggested that root size, shape, hardness and arrangement might play an important role in conferring resistance in the field[6,13,14]. According to Rao[15], host plant resistance plays an

Table 3: Effect of time of harvest on yield and *Cylas puncticollis* (Boh.) attributes of sweetpotato

	Time of harvest		
Attributes	4 MAP	5 MAP	6 MAP
Root yield			
Total number	74383.00±2488.93[b]	80432.00±2797.69[a]	64691.00±3203.28[c]
Total weight	13.98±0.50[c]	21.53±1.00[a]	18.85±0.89[b]
Marketable number	30926.00±1051.57[b]	40679.00±1686.65[a]	28704.00±1868.03[b]
Marketable weight	10.20±0.44[c]	18.01±0.95[a]	15.86±0.81[b]
Cylas puncticollis			
Score	2.00±0.07[c]	3.07±0.12[b]	4.28±0.09[a]
Adult	1.54±0.12[c]	5.51±0.17[b]	9.11±0.27[a]
Immature	4.68±0.35[c]	12.33±0.35[b]	17.91±0.47[a]
Infestation (%)	24.41±1.30[c]	47.94±1.37[b]	63.99±1.29[a]
Damage (%)	15.57±1.09[c]	36.63±1.26[b]	66.74±1.39[a]

Means within a row followed by the same letter do not differ significantly from each other (p>0.05, SAS, PROC GLM, SNK)

important role in the management of serious insect pests. Apart from the nutritional quality of its tuber, the physical attributes of sweetpotato, including its flesh colour, neck length, shape, thickness and skin colour, influence the infestation by sweetpotato weevils. The OFSP variety, CIP440293 yielded higher than TIS8164 and TIS86/0356 and with relatively higher susceptible to *C. puncticollis*. This might be attributed to the presence of boehmeryl acetate, a kairomone identified in sweetpotato roots surface, acts as an ovipositional stimulant for female weevils[16]. Nottingham *et al.*[17] discovered triterpenol acetate on the root surface of the OFSP genotype "Centennial" has shown similar function to other kairomones. This suggested that selection of sweetpotato genotypes with decreased concentration of kairomones such as boehmeryl acetate and triterpenol acetate may significantly facilitate sweetpotato resistance to weevils[15]. The study also revealed that sweetpotato variety TIS86/0256 had the least yield but was the most resistant to weevil infestation.

Soil around roots in flat enjoys greater soil compaction thereby reducing access to roots by weevils when compared with mound and ridge, unfortunately, planting on flat leads to relatively poor root yield. According to Gurr *et al.*[18], ecological engineering is about manipulating farm habitat (including soil), by making them less favourable to insect and more attractive to beneficial insects. The yields (total and marketable) were significantly higher on mound and ridge than on flat. Kimber[19] made a similar observation. The increase in yield on mound and ridge was accompanied by increase in weevil population and subsequent damage. In earlier works, Stathers *et al.*[10] reported that agronomic changes to increase yield are likely to increase levels of infestation as mound and ridge methods supported higher root yield than the flat method.

Time of harvest was also critical for root infestation and damage by *C. puncticollis* as sequential harvesting at 5 and 6 MAP increased these attributes. Sutherland[20] reported a linear relationship between the increases in percentage damaged roots and time. Works in Hawaii also suggested that damage increases sharply between 5.5-7 MAP[21]. Dryness of soil and bulking of roots causes cracking of the soil which exposes the roots and allows the weevil to have greater access to the roots for oviposition. This agrees with previous research that concluded that existing levels of resistance are likely to be overcome by high insect population pressure[22]. Furthermore, previous studies found that increased temperature and rainfall increase soil moisture and make access to the roots for oviposition by adult female *C. puncticollis* difficult since the weevil cannot dig[21] and can burrow only very short distances through the soil[23,24]. Therefore, root yield (weight) reduction at 6 MAP might be attributed to root dehydration caused by soil cracking and increased weevil tunneling (activity) resulting from high temperature and low rainfall.

CONCLUSION

The results showed significant varietal influence among sweetpotato roots to yield and *C. puncticollis* infestation irrespective of the tillage method used. Sweetpotato cvs.TIS2532.op.1.13 and TIS87/0087 consistently gave significantly higher yield and was consistently more susceptibility to *C. puncticollis* than the other cultivars. Carotene-rich (var. CIP440293) had moderate yield and susceptibility to *C. puncticollis*. Conversely, TIS86/0256 consistently produced significantly lower yield and was consistently less susceptible than the other cultivars tested. Although, planting on flat significantly reduced weevil incidence and damage but compromised root yield irrespective of time of harvest. Note that sequential harvesting may result in reduced fresh weight of roots but may not reduce its dry matter which is of major importance to processors.

ACKNOWLEDGMENT

My gratitude is to Mr. Nuhu, K. for technical assistance during the study.

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