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Seasonal Abundance and Variability of Damages Inflicted by Sweetpotato Weevils in Central Tanzania

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Abstract: The sweetpotato production in Tanzania has been increasing due to the changing status of the crop from famine relief to a commercial crop particularly in the central zone of Tanzania. Production of the crop is affected by environmental and biotic stresses. Apart from prolonged drought which affects timely availability of planting materials, sweetpotato weevils were recently reported by growers as a major setback to the productivity of the crop. The study was conducted between December 2016 and July 2017 in Gairo and Ikungi Districts of Morogoro and Singida regions respectively. The aim was to identify sweetpotato weevil species existing in the area, determine the seasonal abundance of the pests and test the response of popular and farmers' preferred sweetpotato varieties to the pest. The effect of planting time on the abundance of sweetpotato weevils was also studied. It was established that *Cylas puncticollis* is the lone weevil species infesting the crop in the study area. Time of planting significantly ($p < 0.05$) influenced weevils' abundance with early planted crop sustaining least number of pests compared to the late planted. Sweetpotato variety, Gudugudu was least damaged by *C. puncticollis.* Locational influence suggested that Gairo District sustained greater weevil abundance and associated damages compared to Ikungi District. It was concluded that planting dates had influence on seasonal abundance of sweetpotato weevil with early planted crop sustaining least infestation with *C. puncticollis* compared to late planted crop.

Key words: Sweetpotato, *Cylas puncticollis*, seasonality, varieties, Tanzania.

1. Introduction

Sweetpotato, *Ipomea batatas* L. Lam, is one of most important crops in Africa which plays a significant role in the global food security [1]. Its production and utilization ensure food security and income generation among the poor segment of the rural population [2]. In Tanzania, sweetpotato is the second-most important root crop after cassava [3]. It contributes significantly to livelihoods of many households. Sweetpotatoes are grown for food and feed in many developing countries [2]. The food security significance of the crop is often appreciated during famine periods as it tolerates drought and grows rapidly to produce storage roots [4]. In Tanzania it is mostly grown by subsistence farmers [3]. The ability to grow potatoes in a wide range of climates and the crop adoption by a broad range of cultures has increased potato consumption worldwide [5]. As a result, it is becoming an increasingly important source of rural employment and food source for growing populations [6]. Its plasticity to environmental conditions and its yielding capacity also make it the best crop for food and nutrition security [7].

In spite of the importance of sweetpotato in alleviating rural poverty, health and food security in Africa and Tanzania in particular, its production and productivity are affected by a number of constraints including diseases, insects and vertebrate pests, weed infestation, soil nutrient deficiencies, poor crop husbandry practices and socio-economic factors [8]. The average fresh root yield at farm level in Tanzania is estimated at 9.5 t/ha [1, 9] which is far less than the international average of 25 t/ha. Studies conducted in Ethiopia and Tanzania, indicated that pests, diseases, drought, and rain shortage were among the main

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factors affecting the sweetpotato yields [10, 11]. Of these factors, insect pests are considered the most limiting, with the *Cylas* spp. complex being the most widely distributed and destructive group [12], *Cylas puncticollis* Bohemanis especially one of the most important biotic constrains to sweetpotato production in East Africa [11, 13-15].

Sweetpotato weevils, of the genus *Cylas* are the most destructive insect pests of the crop at field level [12]. Even at low populations, the weevils reduce yield and quality of root tubers [16]. Attack by the weevils elicits the production of bitter tasting and toxic terpenoids which render infested roots unfit for human consumption [17]. Sweetpotato weevil damages vines, roots and occasionally the foliage, reducing both the yield and quality of the crop. Some control practices like chemical and biological interventions have been proven ineffective due to the cryptic feeding nature of the pest [18]. The sweetpotato weevil infestations can lead to losses in crop yield of up to 50 % [13]. The average yield losses from field to root storage facilities are as high as 60% to 97 % [19, 20]. Crop loss due to sweetpotato weevils may however, vary from place to place, time to time, variety to variety and even the different stages of crop phenological development. Yield loss is high towards the dry season due to low soil moisture, low biomass yield and high soil cracks [20]. Weevils are widely dispersed in tropical regions of the world. Their management is a key issue faced by farmers in major sweetpotato producing countries. The weevils are generally nocturnal, although may also fly during the day in response to a pheromone source [19]. Adult weevils fly freely during the warm part of the year and are capable of at least 1.6 km per season [21]. Previously, weevils have been reported in the Lake and Southern zones of Tanzania [11, 15] with scanty incidences in the Central zone. However, recent observation has noted increased incidences of sweetpotato root damages in the Central zone of the country despite the lacking knowledge of exact weevil species causing such damages. Interview with famers suggested that weevil damages vary depending on time at which the crop is harvested and commonly grown sweetpotato varieties respond differently to weevil damages. Fixing such knowledge gaps was imperative.

Report on the rapid increase in weevil damage of sweetpotato roots in recent years in central Tanzania [22] obviated the need for assessment and characterization of the pest. Apart from identification of the existing pest species an establishment of cropping seasons during which pest incidences are high was a vital component of pest management strategies. The influence of staggered planting and sweetpotato varieties on weevils' incidence was also examined in the present study.

2. Materials and Methods

2.1 Study Location

The study was conducted in Gairo and Ikungi Districts in Morogoro and Singida regions respectively between December 2016 and July 2017. Gairo District lies on the geographical co-ordinates of 06°08′ S, 36°52′ E and Ikungi District on 05°08′ S, 34°46′ E. These districts were selected because they are of high production of sweetpotato in central Tanzania. The areas are characterized by predominantly unimodal rain (average annual range of 400 to 800 mm) followed by prolonged dry spell of 5 to 6 months. Gairo District is a hill (class T-Hypsographic) located at an elevation ranging between 1,230 and 1,370 m above sea level (masl), with maximum temperature of about 22 °C [23] and the soil is predominantly highly weathered red clay that tends to crack when dry. Ikungi is almost flat with slightly slopping elevation of 1,540 masl with highly weathered sandy loam soils [24].

2.2 Experimental Design, Establishment and Managing the Experiment

The experiment was set in a split-plot design laid out in a randomized complete block design (RCBD). Treatments were varieties (Main plots) and time of planting (Sub plots) replicated three times. Variety treatments were Simama, Gudugudu, Matayaand Polista. Time of planting (sub-plot treatments) was early (December), mid (January) and late (March). Planting materials were obtained from the Crop Museum of Sokoine University of Agriculture. Tip vines of about 30 to 40 cm long with approximately 8 nodes were collected from the nursery beds. Planting materials were cut from a three-month old crop. Cut vines were kept under a moist cloth in the shade for 5 d to promote nodal rooting before planting in the field. Vines were planted on bed at an equidistance of 30 cm with the 2/3 of the lower portion buried in the soil at about 10 cm deep. Each bed was 0.4 m high, 1.0 m wide by 3.0 m long. Ridges were spaced at 0.50 m from one bed to another. The plot size was 19.5 m^2 for each treatment culminating to a total experimental area of 175.5 m^2. Bed preparation was done one week before planting. Same experiment was set at two different locations in Gairo (Malimbika and Madege Villages) and two locations in Ikungi (Siuyu and Kimbwi villages). Recommended field management practices inclusive of timely weeding and earthing up around vines were adhered. Planting was done sequentially starting from December, January and March (early, mid and late rainy planting seasons).

2.3 Data Collection and Analysis

Collected data include: number of trapped adult weevils per trap and extent of weevil damages to the vines. Data were collected thrice from each planting season (planting dates) viz; 40 days after planting (DAP), 80 DAP, and 120 DAP.

2.4 Weevil Trapping

Trapping of weevils was done throughout the growing season using the International Potato Centre (CIP) trap design [25] with minor modifications. Immediately after planting, 5 L gallon bait traps were placed in each of the experimental block (one trap per plot) (Fig. 1). This was a modification of CIP trap of 3 L gallon after the 3 L gallon was filled with rain water during the pilot experiment which consequently flashed out the trapped weevils (Fig. 1). The traps were randomly placed on the ground in the experimental plots.

(a) (b)

Fig. 1 Sweetpotato weevil trap; 3 L gallon by CIP (a) and modified traps 5 L gallon (b).

A one-meter long stick was stuck into the soil near the trap and the gallon trap was reinforced onto the stick using manila ropes. To avoid escape, the traps were quarter filled with water and 100 g of sweetpotato lure previously fermented for 7 d. Trapped adult weevils were collected once every 2 weeks. The extent of insect damage to the vines was determined by randomly selecting 2 planted vines, measuring 10 m length of a vine immediate from the soil from each treatment plot and estimate extent of weevil damages through visual observation on leaves using 1-5 damage scale as described by Stathers [26] whereby: 1 = 0% damage, 2 = 1%-25%, 3 = 26%-50%, 4 = 51%-75% and 5 = 76%-100%.

Square root transformation was undertaken on weevil capture counts to normalize the data. Data were subjected to the analysis of variance, with mean separation by Tukey's test at $p \leq 0.05$ level of significance using Gen-Stat statistical package.

3. Results

3.1 Species Composition in the Study Area

The results showed that *C. puncticollis* was the only one species occurring in central Tanzania. The highest numbers of weevils were captured in experimental plots in Madege village in Gairo District. Siuyu village had the highest catches in Ikungi District although comparatively lower than those of either site in Gairo (Table 1). Distinctive characteristics of the trapped insect species were being black in colour, slender bodies and had straight antennae.

3.2 Seasonal Abundance and Effect of Planting Time on Weevil Occurrence

Regardless of planting date, the abundance of the insects seemed to be higher with advancement of the growing season. In both Ikungi and Gairo Districts, the number of captured insects at 40 DAP was higher as season moved away from December (Fig. 2). For December planting, 40 DAP was in January and the number of captured insects was < 0.5 average for Ikungi District and close to 6 for Gairo. For January planting, 40 DAP was in February and number of insects was > 2 for Ikungi and close to 12 for Gairo; while for March planting the number of captured insects was > 5 for Ikungi and > 15 for Gairo whereupon 40 DAP was in April. Thus, we can say that average number of captured insects was > 0.5 for Ikungi and about 5.5 for Gairo in January; about 2.5 for Ikungi and 11.5 for Gairo in February; and about 5.5 for Ikungi and 15.2 for Gairo in April. A similar trend was observed for 80 DAP trappings.

Results revealed that planting time has influence on incidence and distribution of sweetpotato weevils in the field. The average number of trapped weevils was found to vary significantly ($p < 0.05$) among the dates of planting. Highest number of trapped weevils was recorded on a crop planted in March for both 40 and 80 DAP counting, and on an overall average (Fig. 3); while the least numbers were trapped on crop planted in December. The average number of weevils trapped in January planting plots was intermediate and did not show a significant difference ($p > 0.05$) from catches in December and March.

Table 1 Average number of trapped weevils species per plot in the study area.

District	Village	Number of *Cylas* species per month		
		C. puncticollis	*C. brunneus*	*C. formicarius*
Gairo	Madege	69	Nil	Nil
	Malimbika	60	Nil	Nil
Ikungi	Siuyu	21	Nil	Nil
	Kimbwi	15	Nil	Nil
	Total	165	Nil	Nil

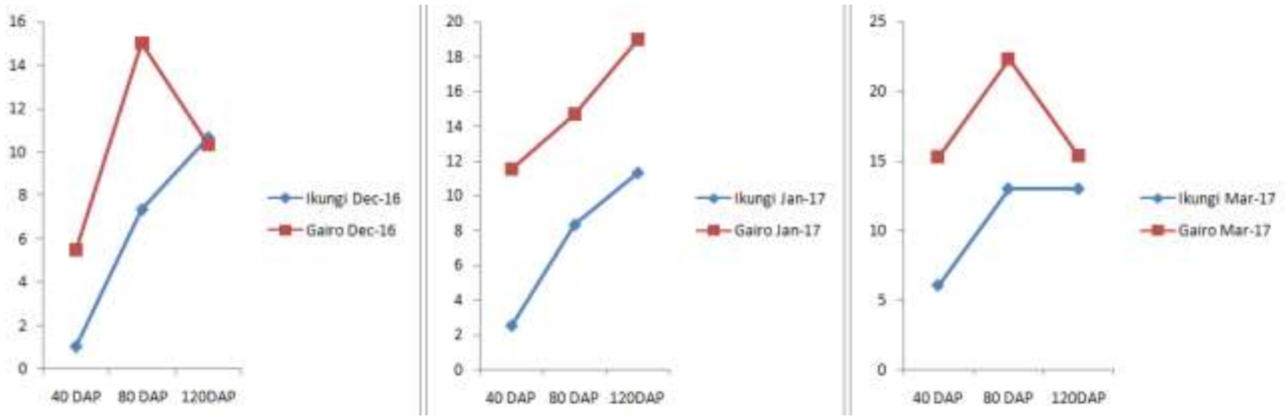

Fig. 2 Mean trapped weevils' number under staggered planting in December, January and March in Ikungi and Gairo districts.

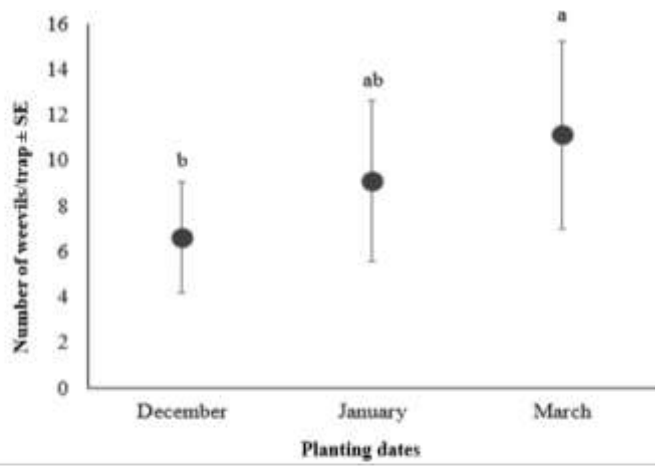

Fig. 3 The number of weevils trapped at different month of planting in both Ikungi and Gairo districts.
Mean points with different letters as data labels are significantly different by Tukeys' test ($p < 0.05$).

3.3 Population Dynamics of the Weevils in Relation to Sweetpotato Planting Time

The population of adult weevils increased with advances in the growing season in both Gairo and Ikungi Districts (Fig. 4). Some decrease was observed at the end of February and early March in separate analysis for both Ikungi and Gairo Districts. It however increased again from March to July. The highest population density was established from captures in May in Gairo District while in Ikungi the pick capture was recorded in July. Planting date was observed to have influence on weevil abundance whereby late planted crop recorded highest number of weevil capture. Generally, weevils were more abundant in Gairo District than Ikungi District. High population of weevil was noted to occur during dry spell period (February, May, and July) in the area.

3.4 Variability of Damage by Sweetpotato Weevil in the Study Area

Levels of pest damage on the same variety tested differed between locations. For example, Gudugudu was having zero percent damage in Kimbi village (Ikungi District) but about 8% damage in Madege village (Gairo District) under the same management. Madege village was noted to have more damage to all varieties tested compared to other locations. Generally, the level of weevil damage in tubers of the potato variety was significantly higher in Gairo District than in plots Ikungi District (Fig. 5). Areas with more pest damage were noted to bear higher losses. Siuyu and Malimbika villages were almost sustaining the same weevil infestation magnitude.

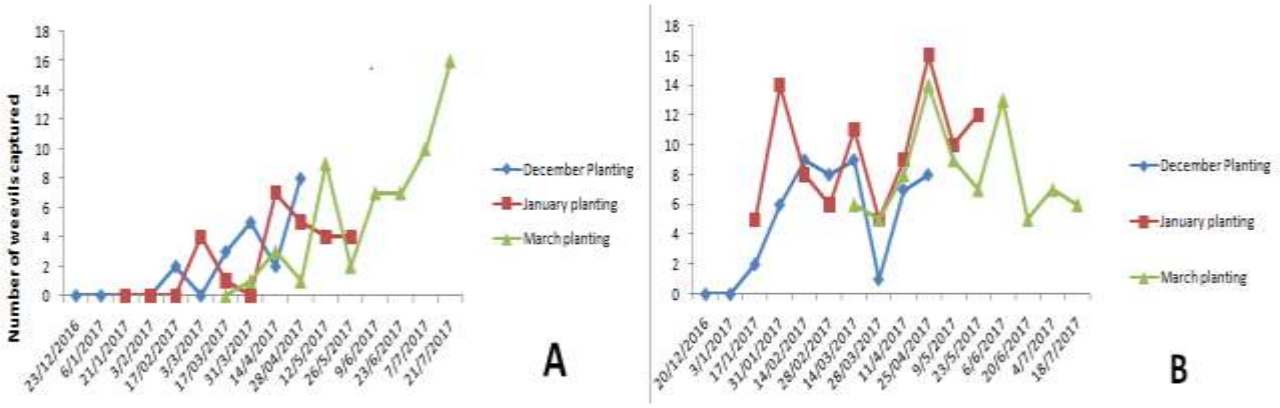

Fig. 4 Adult weevil captured over the growing season in Ikungi (A) and Gairo (B) districts.

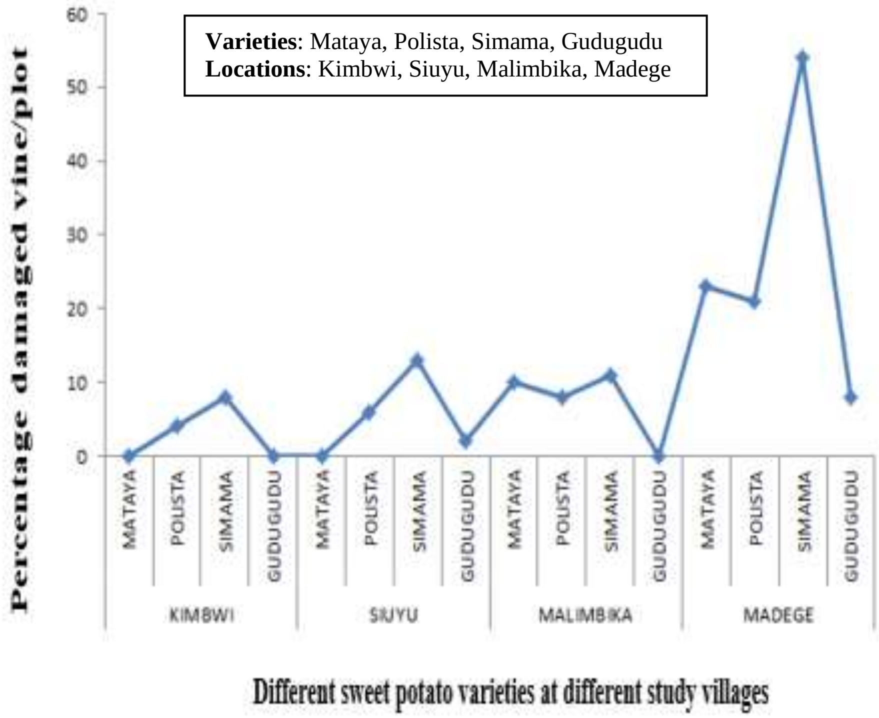

Fig. 5 Damaged sweetpotato vine with respect to varities and locations.

4. Discussion

The present study established *C. puncticollis* as a dominant sweetpotato weevil species in Central Tanzania. This species was at greater abundance and caused severe damage in Gairo District than in Ikungi District. Although it was originally perceived that weevil species reported to exist in other parts of Tanzania inclusive of *C. puncticollis* and *C. brunneus* [3, 15, 27] do exist in Central Tanzania, the current study confirmed that *C. puncticollis* is a lone species affecting sweetpotato in the zone. Other studies report this species to be native to Africa regardless of the distribution [28]. The occurrence of *C. puncticollis* in all fields where experiments were conducted in the current study suggests that the species is very versatile and highly adapted to all different types of environments in central Tanzania.

Cylas brunneus is also known to be existent in East Africa [29] particularly the Lake zone of Tanzania but appears to be absent in central Tanzania. The absence of *C. brunneus* in the study area suggests that it prefers more stable conditions and may also have problems to colonize, disperse, or survive in areas with prolonged drought and great variation in temperature like Central Tanzania. *Cylas brunneus* has been reported to be highly sensitive to extreme temperatures and cannot develop, survive or reproduce at temperature conditions less than 15 °C and above 35 °C [30]. The optimal temperature conditions for development and fecundity occur between 25 °C and 30 °C. Nonetheless, the presence of both *C. puncticollis* and *C. brunneus* at high altitude (2,400 masl) in Kabale District in Uganda was reported [31] which suggested a possible geographical shift by the weevil to higher altitudes. In current era of global warming dynamics and ecological shift of insect pests to area originally not best suited could be expected. Thus, the central zone of Tanzania may not be completely safe from *C. brunneus*. Apart from unsuitable weather conditions of central Tanzania, the current study could not establish other causes for absence of *C. brunneus.* Detailed ecological studies would be required in future to unveil the actual cause of such distribution.

Observation of occasional decreases in numbers of weevils captured may have resulted from mating activity and dormant stages that exist as a result of unfavorable weather condition. Weevils apparently become inactive during period of excessive rainfall and low temperatures. Available report indicated similar observation [32] that *C. puncticollis* with longer oviposition rate can survive in extended periods when oviposition sites are not available and then resume egg laying when conditions improve.

Results on the weevils' abundance revealed that more weevils occur in late planted crop than early planted one. This was attributed to cumulative building up of weevil population from the start of rainy season. The abundance of *Ipomeabatata*, the preferred host and alternative hosts of *Ipomea* sp. from the start of the cropping seasons in late November allowed breeding and perpetuation of the pest hence increased abundance as the season advanced. This is further justified by the lowest counts in December planting after which the number increased substantially in January planting despite the statistical insignificance. Similar finding has been reported [33] that more weevil damages and occurrences were recorded on late planted fields. The influence of intermittent dry season in late January and almost the whole of February could have paved a way to the cracking of the soil allowing further entrance and infestation of the sweetpotato roots with weevils. Soil cracks foster entrance of weevil down the soil. This concurs with the report [15] that the intensity of sweetpotato weevil infestation varies between wet and dry seasons with more incidences being reported during the dry season. Other researchers [3] reported on the significant economic damage inflicted by sweetpotato weevils in areas with marked dry seasons.

Magnitude of weevil damage was observed to differ among varieties planted. Simama variety was severely damaged followed by Polista, Matayawhile Gudugudu was the least infested in all experimental locations. Morphological variation in which some varieties set their roots deeper in the soil while others remain on sub-surface soil layers was considered a major cause for the observed differences among the tested varieties. Such morphological characteristics are believed to be genetically controlled. Available report [33] indicated that the level of resistance of Koka-26 and Cemsa varieties tested against weevils in Areka fields was caused by genotypic variation. However, other workers [20] reported that there are no resistant varieties to the sweetpotato weevil although varieties differ in the degree of damage and infestation by the pest due to root setting in the soil. Given the sustained level of crop damages by *C. puncticollis* great strides should be fostered on research for technologies to sustainably manage the pest that will greatly boost sweetpotato production and impact positively on the livelihoods of farmers in central Tanzania.

Damage by sweetpotato weevil in the study area differed among the same variety tested in different location. This may be due to different soil and weather conditions, which facilitated the survival and multiplication of weevil in the soil. Physical characteristics of the soil have been reported to promote the infestation with sweetpotato weevils [34]. Gairo District is dominated by clay soils characterized by extensive cracking during the dry season or in period of intermittent drought during the growing season, which enables weevil entrance down the soil. This phenomenon was not observed in Ikungi District which is dominated by sandy soils. Generally, high infestation levels have been recorded under dry conditions due to many cracks associated with drying of soils [34, 35]. Furthermore, Ashebir [35] reported that the extent of yield loss was observed to be high towards the dry season due to low soil moisture, low biomass yield and high soil cracks.

Results on location effect revealed that villages in Gairo District had higher weevil damage than those of Ikungi District. The high damage was attributed to high population of *C. puncticollis* in the study area. Some weevil species are comparatively more destructive than others as is the case with *Cylas forimicarius* which is reportedly the most destructive sweetpotato weevil worldwide [36] and its presence even in small number may warrant intensive management [23]. As the case of the present study, *C. puncticollis* is not only super abundant in central Tanzania but also exerts excessive damages to the sweetpotato roots which is economically threatening to farmers.

The present study confirmed that *C. puncticollis* is the lone weevil species infesting sweetpotato in central Tanzania. Planting dates had influence on seasonal abundance of sweetpotato weevil with early planted crop sustaining least infestation with *C. puncticollis* compared to late planted crop. Thus, early planting would be the best cultural method for the avoidance of damages inflicted by *C. puncticollis* in the study area. However, challenges remain on the timely availability of the planting materials at onset of growing season. Generally, the study sites in Gairo District sustained greater *C. puncticollis* infestation than sites in Ikungi District suggesting that intensive management efforts should be directed to the former District. The tested varieties variably succumbed to *C. puncticollis* damages suggesting that choices of varieties with characteristics like Gudugudu could provide an alternative to avoid losses associated with the pest.

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