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Response of banana hybrids to the banana weevil (*Cosmopolites sordidus* Germar) (Coleoptera: Curculionidae) in Uganda

I.K. Arinaitwe[1], E. Hilman[1], R. Ssali[1], A. Barekye[1], J. Kubiriba[1], G. Kagezi[1], H. Talwana[2], C. Nankinga[1], P.E. Ragama[2] and W.K. Tushemereirwe[1]

[1]National Agricutural Research Organisation (NARO), National banana research programme, Kawanda, P. O. Box 7065, Kampala, Uganda
[2]College of Agricultural and Environmental Sciences, P. O. Box 7062, Makerere University, Kampala, Uganda

Author for correspondence: ivanarinaitwe@kari.go.ug

Abstract

Banana weevil (*Cosmopolites sordidus* (Germar) is one of the major constraints to banana production in Uganda. A field screening experimentwas undertaken at Kawanda to determine the response of 18 hybrids to the banana weevil (*Cosmopolites sordidus* (Germar).Based on total cross-sectional damage, results indicated that there was improved resistance to banana weevil in the hybrids tested. Damage scores for all the tested hybrids were significantly different from the susceptible check (Atwalira). Except M4, M5, M6 and M8, the rest of the hybrids showed significant difference from the resistant cultivar (Yangambi KM 5). Data on mat disappearance showed that hybrids were more stable than the susceptible check, while findings from weevil trap catches suggested no relationship between attraction and weevil damage. Resultsshowed that some hybrids have superior agronomic and yield characteristics, however due to high weevil infestation, the findings of the study were not representative of maximum yield potential that may be achieved under good management practices.

Key words: Banana hybrids, *Cosmopolites sordidus*, resistance

Introduction

Banana is an important crop in Uganda with respect to incomes and food security, however productivity is threatened by a number of factors among which is the banana weevil (*Cosmopolites sordidus* (Germar)). Host plant resistance is a key component of integrated pest management in banana systems. Banana, especially the East African Highland (EAH) banana is one of the most important food and cash crops in Ugandan Agriculture, and many other banana growing areas. Despite the importance of banana production to the Ugandan farmers, the last thirty years have seen a drastic reduction in productivity in the traditional banana growing areas of central and southwestern Uganda. This has been attributed to pests, diseases, soil infertility among others and among the most serious constraints to banana production is the banana weevil (ABSP II, 2005).

Damage is caused by larvae that tunnel as they feed in the corm and pseudostem, leading to stunted growth of plants, reduced fruit size, and plant death under high infestations. Yield losses of greater than 40% have been observed in ratoon cycles ((Rukazambuga *et al*., 1998; Gold *et al*., 2004). Management practices for banana weevil include chemical, cultural, biological and host plant resistance. Among insecticides, Dursban (Chloropyrifos) has been reported to give good control of the banana weevil (Ogenga-Latigo and Masanza, 1996). However, insecticides are not affordable for most banana growers in Uganda.

Currently, a number of cultural control methods are recommended for management of this pest. Clean planting material is the first line of control, and selection of uninfested suckers and paring the propagules before planting is recommended (Gold *et al*., 1998). Trapping of adults weevils using pseudostem traps and destruction of plant residues after harvest also achieves modest reductions of weevil populations (Gold *et al*., 2002; Masanza, 2003). Biological control using predators and parasitoids has been attempted with little or no success (Gold *et al*., 2001). The effectiveness of predatory ants on banana weevil has been tested with limited success in Uganda (Abera *et al*., 2008). Use of entomopathogenic nematodes and fungi has been hampered by lack of effective field delivery methods (Nankinga, 1994). Host-plant resistance is known to be an important component in the development of an integrated pest-management strategy for the control of the banana weevil (Gold *et al*., 2001). The development of resistant cultivars is seen as the long term and more sustainable banana weevil control strategy (Kiggundu *et al*., 2003). In the recent past, some progress has been achieved in screening banana germplasm against banana weevil and a number of cultivars have been identified as possible sources of resistance for breeding programs (Kiggundu *et al*., 2003).

Most resistant cultivars are not cooking types, and this presents a problem to breeders, as cooking types are the staple due to consumer preference (Night, 2006). For example, Kiggundu *et al.* (2003) indicated that most highland bananas and plantains are considered highly susceptible to the banana weevil while others such as Yangambi- Km5 appeared to be moderately to highly resistant. Improving the resistance of cooking types remains a challenge, this implies that attempts to find a lasting solution through breeding have been and must be ongoing. This also implies that banana weevil still poses a challenge with respect to food security and incomes to banana growing communities.

Successful banana weevil attack involve finding host plants, host-plant acceptance (oviposition) and host-plant suitability (larval survival, developmental rate, and fitness) (Kiggundu *et al*., 2007). Host-plant resistance affects any of these processes. Host-plant resistance modalities have been attributed to antixenosis (non-preference), antibiosis, and/or host-plant tolerance (Kiggundu, 2000). A number of physical and chemical factors are known to confer host resistance, for examplephytochemicals, especially the allellochemicals (non-nutrients produced by one organism that affect the behaviour, health, ecology and welfare of another) are important in insect plant interactions. Both volatile and non-volatile compounds may mediate insect plant interactions as attractants, reppellants, stimulants or deterrents to feeding and or oviposition (antixenosis). Antibiosis implies that other compounds produced by the host plant may have adverse effects on the survival and development of the herbivore.

Resistance mechanisms have been investigated in some *Musa* germplasm, and antibiosis (factors affecting larval performance), rather than antixenosis (attraction), appeared to be the most important resistance mechanism in banana (Abera *et al.,* 1999; Kiggundu, 2000; Gold *et al*., 2001). Although some differences in attracting adult weevils to different cultivars have been identified, no direct correlations between weevil resistance and plant damage were found (Abera *et al*., 1999; Kiggundu, 2000). It has been reported that differences in attraction have been due to environmental factors such as soil moisture around a cultivar with high sucker number and several banana plant phenological factors contributing to weevil resistance. Corm hardness was the first biophysical factor associated with resistance.

Whereas, Pavis and Minost (1993) found a negative correlation between corm hardness and weevil damage, Ortiz *et al*. (1995) found no relationship between the two parameters in some plantain progenies, and suggested that other weevil resistance factors such as chemical toxins or anti-feedants might be playing role in weevil resistance. Kiggundu (2000) found that corm dry matter content, resin/sap production and suckering ability were negatively correlated with weevil damage. Corm dry matter content, corm hardness, resin/sap production and suckering ability (number of suckers) were significant parameters in the resistance response of some clones introduced in East Africa. In plants with large corms, the weevil larvae can complete their life cycle without burrowing too deep into the corm (Kiggundu, 2000).

The search for resistance and development of resistant cultivars has become a major research priority, and as such, breeding efforts have developed banana hybrids from crosses of the East African Highland Banana varieties and Exotic cultivars having some appreciable levels of resistance by the National Agricultural Resarch Organisation (NARO) at Kawanda. While these materials are being screened for other production constraints as diseases and nematodes, there is need to asses them for resistance against the banana weevilas a basis to provide useful information for breeding programsand reccomendations to farmers. In this study, a field screening experiment was undertaken to assess weevil damage on the banana hybrids, developed by the NARO, to banana weevil.

Materials and methods

Site description

The screening experiment was established in October 2006 at National Agricultural Research laborotories, NARL, Kawanda. NARL is locted at 0°25'N, 32°32'E, 1190 m above sea level, 13 km north of Kampala. Mean annual rainfall is about 1190 mm year^{-1} with a bimodal distribution. The two rain seasons run from March to June and September to December. Average daily temperatures are 16°C minimum and 29 °C maximum. These conditions are generally representative of major banana growing areas of Central Uganda region.

Experimental design

Twenty one cultivars were assigned in an augmented design in six blocks for the experiment. The test materials included 18 new hybrids developed by the National

Agricultural Research Organisiation (NARO) under the National Banana research Programme, Kawanda and three control varieties. The hybrids are presented here as M-1 to M-18, the control varieties were Yangambi Km-5 as resistant, FHIA 17 as moderate resistant and Atwalira as susceptible. Details on the hybrids and parents are presented in Table 1. The augmented design was preffered due to large numbers involved and limited materials for planting at the time of establishing the experiment for the new hybrids.

Each of the six treatments per block was planted with 20 mats per cultivar, randomised within the plot. Spacing was 2 x 2 m per plant, different from the recommended spacing for farmer fields.This was an early screening experimentnormally carried out within 9 - 12 months after planting. Sword suckers were used as planting material and these were paired to ensure no weevils were carried along with to planting site. Hybrid planting material were obtained from on-farm trials already established in Kasangombe, Nakaseke district, while conrol varieties were obtained from farmers' fields in Mubende. Planting was done in holes of 60 cm in diameter and 60 cm deep.

Infestation with banana weevils

Bananas were infested with 10 banana weevils per plant at 9 months after planting, in the ratio of 1:1 female to male making a population density of 25,000 weevilsha^{-1}which maximised weevil exposure. Banana weevils were captured from farmers fields in Kisseka subcounty, Masaka District using pseudostem traps. Weevil sexing was done according to method by Longoria (1968) to confirm their sex, and a hand lens was used to view punctation on the rostrum to

Table 1. Codes and parentages of the hybrids used in the study

Sn	Code	Hybrid	Parents (F X M)
1	M-1	2729K-1	917K-2 X 8075-7
2	M-2	2729K-2	917K-2 X 8075-7
3	M-3	2625K-1	660K-1 X 8075-7
4	M-4	2734K-1.	376K-7 X 8075-7
5	M-5	11777S-6	365K-1 X 9128-3
6	M-6	9540S-2	401K-1 X 8075-7
7	M-7	9494S-36	917K-2 X SH 3362
8	M-8	12478S-13	927K-2 X 9719
9	M-9	12419S-13	1201K-1 X SH 3217
10	M-10	9509S-5	660K-1 X 8075-7
11	M-11	365K-1	Kabucuragye X Calcuta 4
12	M-12	2409K-3	222K-1 X 8075-7
13	M-13	7798S-2	917K-2 X 9128-3
14	M-14	8386S-19	917K-2 X SH 3217
15	M-15	9187S-8	660K-1 X SH 3142
16	M-16	9494S-10	917K-2 X SH 3362
17	M-17	9750S-13	401K-1 X 9128-3
18	M-18	2695K-4	401K-1 X 7197-2

determine the sex. Ten samples of 20 (twenty) weevils were selected; respectively, 9.0±1.88 and 10.9±1.79 males and females. The weevils were released at the base of all mats in the trial. Six months after release of the weevils, an assesment was made to determine the establishment and multiplication of the weevils, this was necessary before assesment for corm damage would begin. Weevil traps were laid in two blocks and weevil counts per trap recorded, gaving an average of 12.5 weevils per mat.

Corm assesment

Bunch harvesting was done at physiological maturity, when a ripening finger was spotted. Corm damage assesment was conducted 0 - 15 days after harvesting between March and July 2008 using destructive sampling, according to methods described by Gold *et al*. (1994).

Corm damage assesment was conducted after harvesting, at this stage all plant structures have matured. According to Night (2006) full development of plant structures may be neccesary for full expression of resistance. Total cross sectional damage was preffered as a basis for determination of weevil damage. Unlike other weevil damage assesment methods, this shows the highest correlation with total yield loss (Gold, 2005), high yield is the ultimate concern for farmers.

Weevil damage (galleries) were scored as percentage damage on the upper cross-section (at collar area) and lower cross-section (at 10 cm below the collar). The cross-section was scored for both the inner corm (central cylinder) and the outer corm (cortex). According to Gold *et al*. (2005), damage to the central cylinder has greater impact on plant performance than other damages, especially on corm periphery. In this study, assesment was therefore, limited to the corm cross-sections of the central cylinder and outer cortex. Total damage was obtained as the average of cross-section damage of the central cylinder and cortex.

Mat disapearance

Total number of mats in the trial were counted at an interval of six month beginning six months after planting. The data was compared over time to verify the effect of banana weevils on stability of the hybrids.

Weevil trap catches

Weevils were trapped manually using traps made of split pseudostems. Split pseudostems were placed around the mats and left for three days . The total number of weevils trapped were then counted and recorded.

Agronomic characteristics

Bunch weight, girth and height

In addition to corm damage assesment, data was also captured on agronomic parameters.Bunch weight data was captured at harvesting of mature banana bunches by weighing with a scale. A long demarcated stick was used to determine plant height from ground to point where bunch emerged from pseodostem, while plant girth was determined using a tape measure at 100cm above the ground.

Data analysis

Data analyses were carried out using SAS software version 9.2 (TS1M0) (The SAS Institute Inc., Cary NC 27513, USA). Pearson correlation coefficients (PROC CORR procedure) were carried out on corm damage, agronomic and yield variables to determine association between damage, agronomic and yield components. Total inner damage, total outer damage and total cross-sectional damage were transformed by the arcsine transformation using the formula;

$$Y_{trans.} = 100 * ar\sin\left(sqrt\left(\frac{(Vo+0.5)}{100}\right) * \frac{22}{28}\right);$$

Where:

Y_{trans} = transformed variable, arsin = arcsine transformation, sqrt = square root and Vo is the observed variable. Means were separated using dunnett test (at 5% significant level) of the mixed procedure (PROC MIXED) of the SAS software using the following model.

Y_{ijk}= μ + cultivar + block (cultivar) + Residuals;

Where cultivars were fixed effects and block(cultivar) as random effects and Residuals assumed to be normally distributed with zero mean and variance σ^2.

Results and discussion

There were significant levels of resistance (P<0.05) exhibited by 15 hybrids that were assessed for corm weevil damage compared to the susceptible check cultivar, Atwalira and whereas hybrids M3, M4, M5, M6 and M8 showed no significant difference from resistant check Yangambi Km5, the rest of the hybrids showed a significant difference (Table 2). Less

Table 2. Means (± Standard error) of total cross-section corm damage scores of banana hybrids tested

Cultivar	Mean txt (±)	Compared to Atwalira	Compared to KM5	Compared to FHIA 17
Atwalira	41.7±1.37	41.7±1.37	41.7±1.37	41.7±1.37
KM5	06.2±1.38	06.2±1.38*	06.2±1.38	06.2±1.38
FHIA17	23.9±1.37	23.9±1.37*	23.9±1.37*	23.9±1.37
M1	15.5±1.74	15.5±1.74*	15.5±1.74*	15.5±1.74 NS
M10	15.0±1.89	15.0±1.89*	15.0±1.89*	15.0±1.89 NS
M11	28.7±1.81	28.7±1.81*	28.7±1.81*	28.7±1.81 NS
M12	17.4±1.72	17.4±1.72*	17.4±1.72*	17.4±1.72*
M14	17.7±1.78	17.7±1.78*	17.7±1.78*	17.7±1.78*
M16	17.3±1.86	17.3±1.86*	17.3±1.86*	17.3±1.86*
M17	13.9±1.72	13.9±1.72*	13.9±1.72*	13.9±1.72 NS
M2	15.3±1.72	15.3±1.72*	15.3±1.72*	15.3±1.72 NS
M3	12.5±1.88	12.5±1.88*	12.5±1.88 NS	12.5±1.88 NS
M4	10.6±1.78	10.6±1.78*	10.6±1.78 NS	10.6±1.78 NS
M5	11.8±1.77	11.8±1.77*	11.8±1.77 NS	11.8±1.77 NS
M6	14.3±1.74	14.3±1.74*	14.3±1.74 NS	14.3±1.74 NS
M7	14.9±1.86	14.9±1.86*	14.9±1.86*	14.9±1.86 NS
M8	12.2±1.84	12.2±1.84*	12.2±1.84 NS	12.2±1.84 NS
M9	25.1±1.74*	25.1±1.74*	25.1±1.74*	25.1±1.74*

NS and * indicate non-significant (P> 0.05), significant (P≤ 0.05) from controls by Dunnett's test damage was recorded in the inner cylinder (damage levels ranging from 06.62 ± 1.75 to 22.54 ± 1.78) than to the cortex (13.37 ± 2.00 to 33.70± 2.03) (Table 3).

Our results indicate that most hybrids exhibit moderate to high levels of resistance. All hybrids were significantly different from the susceptible cultivar, Atwalira (P d" 0.05). Hybrids M3, M4, M5, M6 and M8 exhibited high resistance levels; they did not show significant difference from the resistant cultivar, Yangambi Km5 (P > 0.05) using total cross sectional damage (Table 2). As presented in Table 2, M9 and M11 were the most affected at 25.16±1.74 and 28.77±1.81 respectively (5% significance level), nevertheless damage levels are not significantly different from the intermediately resistant check cultivar – FHIA17 (P > 0.05) and can therefore be considered moderately resistant.

Using cross sectional inner damage, M1,M11, M14 and M16 showed no significance difference with the resistant check Yangambi Km5. These hybrids can be preffered for weevil resistance since the most important damage on the corm is cross sectional inner. This damage interferes with mineral and water uptake from the soil thus adversely affetcing the plant (Gold *et al*., 2005). According to Gold *et al*. (2005) damage in the central cylinder is the best predictor of damage and yield loss. The lower damage levels observed in the central cylinder of all

Table 3. Means (± Standard error) of inner and outer corm damage scores of banana hybrids tested

Cultivar	Total inner damage		Total outer damage	
	Compared to Atwalira	Compared to KM 5	Compared to Atwalira	Compared to KM 5
Atwalira	33.52 ± 1.21	33.52 ± 1.21	48.38 ± 1.58	48.38 ± 1.58
FHIA 17	16.31 ± 1.20	16.31 ± 1.20	29.43 ± 1.57	29.43 ± 1.57
KM 5	05.56 ± 1.21	05.56 ± 1.21	06.69 ± 1.58	06.69 ± 1.58
M 1	11.46 ± 1.70*	11.46 ± 1.70^{NS}	18.23 ± 1.96*	18.23 ± 1.96*
M 10	09.74 ± 2.00*	09.74 ± 2.00*	18.54 ± 2.11*	18.54 ± 2.11*
M 11	22.54 ± 1.78*	22.54 ± 1.78^{NS}	33.70 ± 2.03*	33.70 ± 2.03*
M 12	12.04 ± 1.68*	12.04 ± 1.68*	21.27 ± 1.94*	21.27 ± 1.94*
M 14	11.67 ± 1.76*	11.67 ± 1.76^{NS}	22.06 ± 2.00*	22.06 ± 2.00*
M 16	11.67 ± 1.76*	11.67 ± 1.76^{NS}	21.76 ± 2.08*	21.76 ± 2.08*
M 17	08.09 ± 1.67*	08.09 ± 1.67*	17.84 ± 1.93*	17.84 ± 1.93*
M 2	09.93 ± 1.67*	09.93 ± 1.67*	18.98 ± 1.93*	18.98 ± 1.93*
M 3	08.64 ± 2.10*	08.64 ± 2.10*	15.31 ± 2.11*	15.31 ± 2.11*
M 4	06.62 ± 1.75*	06.62 ± 1.75*	13.37 ± 2.00*	13.37 ± 2.00^{NS}
M 5	08.43 ± 1.74*	08.43 ± 1.74*	14.07 ± 2.00*	14.07 ± 2.00^{NS}
M 6	09.65 ± 1.70*	09.65 ± 1.70*	17.40 ± 1.96*	17.40 ± 1.96*
M 7	10.12 ± 1.87*	10.12 ± 1.87*	18.33 ± 2.09*	18.33 ± 2.09*
M 8	07.25 ± 1.84*	07.25 ± 1.84*	15.53 ± 2.07*	15.53 ± 2.07*
M 9	16.93 ± 1.69*	16.93 ± 1.69^{NS}	31.09 ± 1.95*	31.09 ± 1.95*

^{NS} and * indicate non-significant (P> 0.05), significant (P≤ 0.05) from controls byDunnett's test hybrids than to the outer cortex probably implies that the observed damage may not have a significant effect on yield. These result therefore suggest that the hybrids screened in this experiment have mostly modearte resistance and some few have high resistance as high as the resistant check Yangambi Km5. This is an achievement since the hybrids have a form of host plant resistance and if the hybrids are relaesed by the release committee, formers will not have to part with the costs of buy pesticides or measures to control the banana weevils.

Agronomic characteristics

Mean plant girth for M2, M3, M9, M14, M16 and M17 are not significantly different from Atwalira (P>0.05), (Table 4), an acceptable cultivar among farmers.

Results from the screening experiment indicate that a number of hybrids have good agronomic characteristics**.** These hybrids are considered to have positive attributes because from the current study, there is a positive correlation between plant girth and bunch weight (R^2 = 0.85). These hybrids having the same agronomic attributes to an acceptable cultivar among farmers, the release committe and farmers will not find a big challenge in accepting these hybrids since they don not differ much from their locaaly accepted variety.

Yield characteristics

There were no signicicant difference of M1, M10, M11, M14, M16, M17, M2,M4, M5, M6, M7 and M8 compared to the acceptable cultivar among farmers Atwalira for bunch weight. Als there were

Table 4. Means (± Standard error) of agronomic parameters of hybrids tested in the screening experiment

Cultivar	Mean plant girth		Mean plant height	
	Compared to Atwalira	Compared to KM 5	Compared to Atwalira	Compared to KM 5
Atwalira	45.58 ± 0.90	45.58 ± 0.90	245.81 ± 7.65	245.81 ± 7.65
FHIA 17	64.52 ± 0.90	64.52 ± 0.90	231.86 ± 7.62	231.86 ± 7.62
KM 5	34.42 ± 0.90	34.42 ± 0.90	198.38 ± 7.65	198.38 ± 7.65
M 1	39.98 ± 1.15*	39.98 ± 1.15 ^{NS}	207.08 ± 8.85*	207.08 ± 8.85*
M 10	29.58 ± 1.25*	29.58 ± 1.25 ^{NS}	176.61 ± 9.34*	176.61 ± 9.34*
M 11	39.21 ± 1.19*	39.21 ± 1.19 ^{NS}	217.34 ± 9.06 ^{NS}	217.34 ± 9.06*
M 12	33.47 ± 1.34*	33.47 ± 1.34*	182.82 ± 8.78*	182.82 ± 8.78*
M 14	44.16 ± 1.18 ^{NS}	44.16 ± 1.18 ^{NS}	247.72 ± 8.98 ^{NS}	247.72 ± 8.98 ^{NS}
M 16	40.09 ± 1.23 ^{NS}	40.09 ± 1.23 ^{NS}	210.93 ± 9.26 ^{NS}	210.93 ± 9.26*
M 17	41.89 ± 1.33 ^{NS}	41.89 ± 1.33 ^{NS}	232.36 ± 8.76 ^{NS}	232.36 ± 8.76*
M 2	40.58 ± 1.13 ^{NS}	40.58 ± 1.13 ^{NS}	216.46 ± 8.75 ^{NS}	216.46 ± 8.75*
M 3	43.28 ± 1.25 ^{NS}	43.28 ± 1.25 ^{NS}	232.13 ± 9.33*	232.13 ± 9.33*
M 4	38.13 ± 1.18*	38.13 ± 1.18*	208.99 ± 8.96*	208.99 ± 8.96*
M 5	36.57 ± 1.17*	36.57 ± 1.17*	208.99 ± 8.82*	208.99 ± 8.82*
M 6	35.84 ± 1.15*	35.84 ± 1.15*	202.12 ± 8.83*	202.12 ± 8.83*
M 7	38.20 ± 1.24*	38.20 ± 1.24*	198.07 ± 9.28*	198.07 ± 9.28*
M 8	33.87 ± 1.22*	33.87 ± 1.22*	194.13 ± 9.20*	194.13 ± 9.20*
M 9	45.23 ± 1.15 ^{NS}	45.23 ± 1.15 ^{NS}	255.75 ± 8.81 ^{NS}	255.75 ± 8.81 ^{NS}

^{NS} and * indicate non-significant (P> 0.05), significant (P≤ 0.05) from controls by Dunnett's test no signicicant difference of M10, M11, M16, M17, M2, M3, M4, M5, M6, M7 and M8 compared to the acceptable cultivar among farmers Atwalira for number of hands on the bunch (Table 5).

Bunch weight is one of the most preferred yield aspect of bananas; it is directly related to food security and economic returns for banana growing households. Despite the weevil pressure and the fact that standard banana management practices were not adhered to, results indicate that some hybrids such as M3, M14 and M9 (Table 5) have potential for big bunches especially if recommended management practises are followed. Most farmers prefer matooke that yield highly, therefore since most of the hybrids in this study showed the same yield as a locally preferred variety, there are high chances that the hybrids will easily be acceptable by the farmers. Also there are chances that under no weevils infestation, these hybrids can yield more giving them upper hand on the local varieties. These will be super hbrid varieties putting int considearation the fact that they have resistance to weevils and have yield. This will increase food production and hence increasing income of the small scale farmers.The study findings indicated that the tested hybrids have appreciable levels of resistance as well as agronomic and yield attributes.

Mat dissapearance

The susceptible chec atwalira showed highest rate of mats dsapearance after 12

Table 5. Means (± Standard error) of yield parameters of tested hybrids

Cultivar	Mean bunch weight ± Se		Mean number of hands ± Se	
	Compared to Atwalira	Compared to KM 5	Compared to Atwalira	Compared to KM 5
Atwalira	12.03 ± 0.62	12.03 ± 0.62	06.87 ± 0.19	06.87 ± 0.19
FHIA 17	23.80 ± 0.62	23.80 ± 0.62	12.53 ± 0.18	12.53 ± 0.18
KM 5	10.32 ± 0.62	10.32 ± 0.62	06.74 ± 0.19	06.74 ± 0.19
M 1	14.60 ± 0.75^{NS}	14.60 ± 0.75*	07.93 ± 0.27*	07.93 ± 0.27*
M 10	07.48 ±0.80^{NS}	07.48 ± 0.80^{NS}	06.86 ± 0.30^{NS}	06.86 ± 0.30^{NS}
M 11	09.07 ± 0.77^{NS}	09.07 ± 0.77^{NS}	06.58 ± 0.28^{NS}	06.58 ± 0.28^{NS}
M 12	08.40 ± 0.74*	08.40 ± 0.74^{NS}	05.62 ± 0.26*	05.62 ± 0.26^{NS}
M 14	15.38 ± 0.76^{NS}	15.38 ± 0.76*	08.45 ± 0.28*	08.45 ± 0.28*
M 16	13.23 ± 0.79^{NS}	13.23 ± 0.79^{NS}	06.67 ± 0.29^{NS}	06.67 ± 0.29^{NS}
M 17	13.84 ± 0.74^{NS}	13.84 ± 0.74^{NS}	07.76 ± 0.26^{NS}	07.76 ± 0.26^{NS}
M 2	13.62 ± 0.74^{NS}	13.62 ± 0.74^{NS}	07.42 ± 0.26^{NS}	07.42 ± 0.26^{NS}
M 3	15.52 ± 0.80*	15.52 ± 0.80*	07.55 ± 0.30^{NS}	07.55 ± 0.30^{NS}
M 4	11.20 ± 0.76^{NS}	11.20 ± 0.76^{NS}	06.82 ± 0.27^{NS}	06.82 ± 0.27^{NS}
M 5	10.71 ± 0.76^{NS}	10.71 ± 0.76^{NS}	06.73 ± 0.27^{NS}	06.73 ± 0.27^{NS}
M 6	11.08 ± 0.74^{NS}	11.08 ± 0.74^{NS}	07.48 ± 0.27^{NS}	07.48 ± 0.27^{NS}
M 7	11.78 ± 0.79^{NS}	11.78 ± 0.79^{NS}	07.92 ± 0.30^{NS}	07.92 ± 0.30*
M 8	09.18 ± 0.78^{NS}	09.18 ± 0.78^{NS}	06.19 ± 0.29^{NS}	06.19 ± 0.29^{NS}
M 9	16.74 ± 0.74*	16.74 ± 0.74*	08.09 ± 0.27*	08.09 ± 0.27^{NS}

^{NS} and * indicate non-significant (P> 0.05), significant (P≤ 0.05) from controls by Dunnett's test months whereas resistant check 5 had most mats after 18 months. There was a lttle decline in number of mats after m. Most of the hybrids had stable mats through out the period of study but the few M1,M2,M3 that showed that disappearance was more stable compare both checks as (Fig. 1). In addition to yield losses and plant losses, banana weevil infestation causes mat dissapearance (Gold *et al*., 2004). In the current study, total number of mats were recorded at six months interval. Results indicated a fast rate of mat dissapearence for the susceptible check variety (Atewalira), this was significantly different from the most hybrids, (P<0.05). The sharp decline after 18 months could be attributed to weevil damage and the destructive weevil sampling technique adopted for assesment of weevil damage on the corm. The resistance check Yangambi Km5 had stable mats but the most important aspect is that some of the tested hybrids are more stable that Yangambi Km5 (Fig. 1). This is a good result that these hybrids M1, M2 and M3 can have a better stability under weevil pressure. These can also be sources of resistance to banana weevil for genetic engineers. Such genes will have less concerns from the public since the genes will come from banana to banana. The results obtained give credence to the corm damage results and support to the hypothesis that there is improved resistance in the new hybrids to banana weevil (*Cosmopolites sordidas)*.

Population Density of weevils per cultivar

The population density of weevil on each cultivar was varying, M8, M11and M17 had distinctive number of weevil comparedd to the rest of the cultivar tested (Table 6). The rest of the varieties in Table 6 either show no significant difference in weevil density compared to both checks used in the study.

Prior to weevil damage assesment, weevil density was estimated by weevil trap counts on all the test hybrids and check cultivars. The figures obtained are presented in the Table 6. The pattern observed was quite different from the weevil damage pattern, indicating that there was no relationship between weevil damage and weeevil attraction to the different cultivars. For example, Atwalira

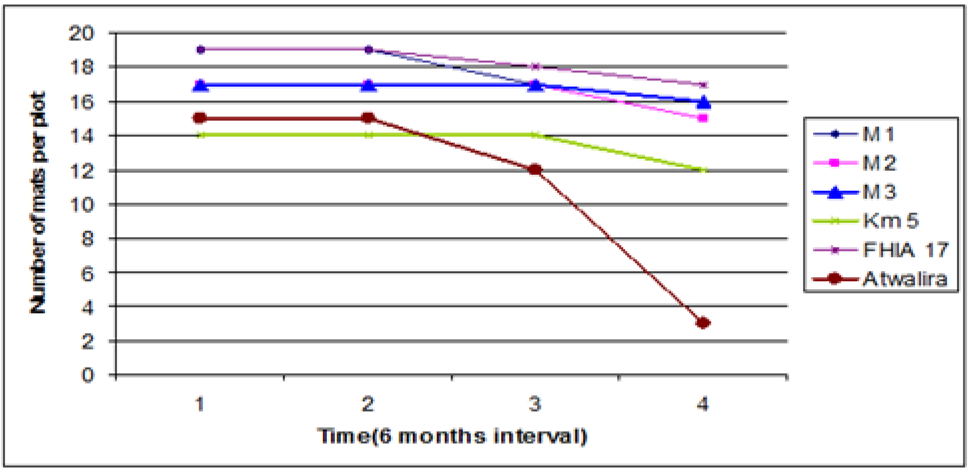

Figure 1. Number of mats per plot over time.

Table 6. Population density of weevils per cultivar

Cultivar	Population density
M8	49583 a
M14	45417 ab
M1	44167abc
M3	41667 abc
M12	38333 abc
M2	36250 abd
M7	34167 abcde
M16	32500 abcde
KM 5	32500 abcde
FHIA 17	32014 abcde
M10	31250 abcde
M6	29167 cde
Atwalira	28333 cde
M9	27917 cde
M13	26667 cde
M15	25833 cde
M4	19167 de
M5	17917 de
M17	17500 e
M11	15833 e

Figures with same letters show there is no significant difference between those figures and figures with different letters mean that those figures are different

and M11 which ranked first in weevil damage did not show significant difference (P>0.05) in attraction from the resistant Yangambi Km5. This corresponds to results obtained by Kiggundu *et al.* (2000) who found no relationship between weevil damage and attraction to the the tested cultivars. Results (Table 2) indicated that the developed hybrids expressed improved levels of resistance to the banana weevil.

Conclusion

All hybrids were significantly different from the susceptible cultivar – Atwalira in terms of corm damagewhile a few which had high total corm damage values similar to resistant variety Yangambi Km5. Most of the hybrids level of damage lies between resistant and suceptible cheks.The study also assessed agronomic and yield parameters, however the study did not follow best banana management practices, for example spacing and fertility management that are reccommended for maximum productivity. In addition infestation with weevils probably implies that the expected productuvity potential was not realised. Nevertheless there were indications of improved / acceptable levels of yield and agronomic performance.

The current study suggests that the developed hybrids have demonstrated improved resistance to banan weevil. These hybrids may be popularised among banana growing communities if they pass the social acceptance test, otherwise they remain candidates as sources of good attributes and can be used in banana breeding research to develop more acceptable matoke cultivars.

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