Crop Protection

Title: Sources of pest resistance in cassava

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Abstract

Cassava (*Manihot esculenta* Crantz), a primary food crop in developing countries, can be severely affected by the attack of several Neotropical pests. To contribute to their management, this study sought to identify genetic resources for resistance breeding within the world's largest cassava genebank, held at the International Center for Tropical Agriculture (CIAT), in Colombia. We compiled data from 89 field trials between 1980 and 2004 evaluating natural mite, thrips, and whitefly herbivory in hundreds of cassava genotypes. Highly susceptible genotypes were excluded from subsequent evaluations within one or two trials. Statistical analyses estimating resistance were therefore performed only for genotypes evaluated for a given pest in at least three trials. These analyses revealed potentially-useful genotype variation in resistance to *Mononychellus tanajoa* (Bondar), *Aleurotrachelus socialis* Bondar, and *Frankliniella williamsi* Hood. Based on this variation, we identified 129 potential sources of resistance to *F. williamsi*, 33 to *M. tanajoa*, and 19 to *A. socialis*. Leaf pubescence was positively associated with resistance to the three pests, and root cyanide was negatively associated with resistance to *A. socialis*. Our results support the potential for developing improved cassava cultivars with high pest resistance.

Keywords *Aleurotrachelus socialis* Bondar · *Frankliniella williamsi* Hood · Host plant resistance · *Mononychellus tanajoa* (Bondar)

Highlights

- We report findings from 89 field evaluations of pest resistance in cassava landraces
- Statistical analyses found 129 landraces with high resistance to thrips, 33 to green mites and 19 to whiteflies
- Leaf pubescence associated positively with resistance to the three pests
- Root cyanide associated negatively with resistance to whiteflies
- Results suggest potential to improve cassava cultivars with respect to pest resistance

1. Introduction

Cassava (*Manihot esculenta* Crantz) is a staple food for about 800 million people in the tropics (Lebot 2009). It is a hardy root crop that demands little management and tolerates harsh soil and climate conditions where most other crops would fail (El-Sharkawy 2004). Partly because of these attributes, the crop plays a central role in food security and carries unique potential for climate change adaptation in developing countries (Burns et al. 2010; Jarvis et al. 2012).

Several arthropod pests can disrupt cassava's contributions to food security (Bellotti and Schoonhoven1978; Bellotti et al. 1999; Herrera Campo et al. 2011). The two most notorious – the cassava mealybug (*Phenacoccus manihoti* Matile-Ferrero) and the cassava green mite (*Mononychellus tanajoa* (Bondar)) – threatened many African countries with the risk of famine when they invaded the continent during the 1970s (Herren and Neuenschwander 1991). Less known, but thought to be similarly destructive, is a complex of monophagous cassava whiteflies largely dominated in the Americas by *Aleurotrachelus socialis* Bondar (Bellotti et al. 1999). In Africa, the polyphagous species *Bemisia tabaci* (Gennadius) is the most important whitefly pest (Omongo et al. 2012). Several thrips species, notably *Corynothrips stenopterus* Williams and *Frankliniella williamsi* Hood, are also considered major cassava pests (Bellotti and Schoonhoven 1978; Bellotti et al. 1987), but their impact is less serious than that of the other arthropods mentioned above (Schoonhoven and Pena 1976; Bellotti et al. 1999). Nearly all are native to tropical South America, the center of origin and diversity of cassava.

A valuable, but still underexploited, opportunity exists to breed cassava for resistance to pests. Researchers at the International Center for Tropical Agriculture (CIAT) have evaluated thousands of cassava accessions for field resistance to some of the crop's most serious pests (Bellotti et al. 1987). Considerable variability was observed to exist for resistance to green mites, whiteflies, and thrips, the three most extensively evaluated pest groups. These evaluations, however, have been only partially reported to date (e.g., Schoonhoven 1974; Bellotti and Byrne 1979; Bellotti and Arias 2001).

Our study therefore aims to integrate and statistically-synthesize the outcomes of these previously unreported evaluations. Thus, we hope to shed light on promising sources of green mite, whitefly and thrips resistance for cassava breeding programs.

2. Materials and methods

2.1. Cassava genebank

The cassava genebank held at CIAT is the largest in the world for this crop. It preserves 6,739 *Mahihot* accessions, most of them collected in Colombia and Brazil (Jaramillo 2012). About 72% of these accessions are traditional cultivars or landraces of *M. esculenta*. The remaining accessions are improved cultivars, wild species, or hybrids. The collection was established in 1969, and maintained as a field genebank for more than two decades while it was gradually replaced by a tissue culture genebank (Roca et al. 1989).

Many landraces in the genebank have been evaluated under one or more of the sequential selection trials carried out by CIAT's cassava breeding program (Ceballos et al. 2004). The first in the sequence is a single-row trial, where 5 to 10 plants per genotype are planted in single-row plots, without replication, at a distance of 1 × 1 m within and between rows. The second is a preliminary yield trial, where plants are arranged in a randomized complete block design, with three replicates and 10 plants per replicate, at a planting distance of 80 × 80 cm within and between rows. The third is an advanced yield trial, where the previous design is maintained but with 20 plants per replicate. The three types of trials are typically planted at the beginning of the rainy season, around April. We compiled data from 89 selection trials between 1980 and 2004. They included 31 single-row trials, 27 preliminary yield trials, and 31 advanced yield trials. More than half of them were conducted at CIAT headquarters in Palmira, Colombia (Table 1).

2.2. Resistance evaluations

Accessions were evaluated for resistance only in sites to which they were well adapted and grew vigorously in the absence of pests. Field sites, and their ecological characteristics, are listed in Table 1. The evaluations were facilitated by natural infestations of *M. tanajoa*, *A. socialis*, and *F. williamsi*, which peak during the dry seasons around August and February. Ratings were based on the damage scales described in Table 2. Although the scales are categorical, the evaluators treated them as continuous, often assigning scores with decimal points. Every plant in the trial was evaluated and scored for damage only upon the trial's first natural pest outbreak, typically around August, four months after planting. Subsequent outbreaks (if any) were not evaluated. To reduce the impact of escapes (i.e. when insect pests were not present), which could be falsely interpreted as resistance, the cassava breeding program only retained and recorded the highest damage score per accession per trial.

In addition to pest resistance, the genebank was also separately evaluated for leaf pubescence based on a 1–4 or 1–7 scale, where 1 signifies less pubescent, and for root hydrogen cyanide (HCN) content (Sánchez et al. 2009). Leaf pubescence is a useful cultivar descriptor, and it is often associated with pest resistance. HCN has also been implicated in pest resistance (Riis et al. 2003a), but high root HCN can render cassava toxic for human consumption. We obtained data for these traits from the CIAT cassava program to test for their association with pest resistance.

2.3. Statistical analyses

Statistical analyses were performed only for cassava landraces evaluated for a given pest in at least three trials (Fig. 1). For these accessions, we estimated pest resistance based on multiple regression analyses of *damage score* as a dependent variable with *accession* and *trial* as fixed effect independent variables. This last variable served as a statistical control for the joint influences of management and environment, therefore controlling for variable pest pressures across sites and years. We then applied K-means cluster analyses to the predicted damage scores for each pest (i.e., estimated resistance) to separate the accessions into three resistance groups (i.e. high, medium, low). Finally, we treated accessions as replicates and used one-way analyses of variance (ANOVA) to test if resistance estimates for each pest were statistically associated with leaf pubescence ratings, and single regression analyses to test if they were statistically associated with root HCN content (log-transformed). Analyses were performed in R version 2.15.1.

3. Results

Most landraces in the study were evaluated only once for a given pest or pest combination (Fig. 1). Among them, 89.5% scored three or higher for damage from whiteflies, which meant that they were excluded from subsequent trials because of their susceptibility. However, 53.9% of once-evaluated landraces scored three or higher for damage from green mites, and 51.1% scored three or higher for damage from thrips. Thus, landraces evaluated once may also include good sources of resistance to green mites and thrips.

A subset of landraces was considered for further evaluations, being assessed three or more times for resistance to our focal pests (Fig. 1). They included 98 landraces evaluated for green mites, 153 landraces evaluated for whiteflies and 280 landraces evaluated for thrips. Only eight landraces were evaluated three or more times for each of our three focal pests; namely, M Col 1468, M Col 1505, M Col 1664, M Col 2019, M Col 2215, M Ven 25, M Ven 77, M Ven 156.

The regression models associating damage scores with accession and trial for green mites ($F = 5.3$, df = 371, $P < 0.001$; $R^2 = 0.64$), whiteflies ($F = 7.1$, df = 326, $P < 0.001$; $R^2 = 0.79$), and thrips ($F = 14.7$, df = 1,338, $P < 0.0001$; $R^2 = 0.78$) suggest significant genetic variability exists for resistance to these pests (Appendix A; Tables 1-3). This variability is characterized in Figure 2, which presents the frequency distribution of pest damage predicted for the trial with the highest observed herbivory. Based on these predictions, Table 3 presents the 10 most resistant landraces against each pest. Cluster analyses classified these landraces into the high resistance groups; which included a total of 129 landraces for *F. williamsi*, 33 for *M. tanajoa*, and 19 for *A. socialis*. The number of landraces within each resistance group and their estimated damage ranges are presented in Figures 3 and 4, respectively.

Leaf pubescence was strongly associated with estimated resistance to green mites ($F = 9.1$, df = 94, $P < 0.001$; $R^2 = 0.23$), whiteflies ($F = 3.2$, df =144, $P = 0.004$; $R^2 = 0.13$), and thrips ($F = 186.3$, df = 276, $P < 0.001$; $R^2 = 0.66$). Their means are presented in Figure 5. In contrast, root HCN showed a statistical association only with estimated resistance to whiteflies (resistance $= 4.00 + 0.33 * \text{Log}_{10}\text{HCN}$; $F = 5.28$, df = 146, $P = 0.023$; $R^2 = 0.04$; Fig. 5).

4. Discussion

Our study's goal was to indicate promising sources of host-plant resistance for cassava breeding programs. We estimated resistance based on plant damage during natural pest infestations. Therefore, our methods cannot elucidate specific resistance mechanisms, but likely capture a combination of antibiosis and antixenosis (see Parsa et al. 2011).

Less than 5% of the cassava genebank holdings at CIAT entered our analyses. Even so, we identified significant variability in resistance to the three targeted pests. These findings mirror those from previous resistance evaluations in cultivated cassava (Schoonhoven 1974; Bellotti and Byrne 1979; Bellotti et al. 1987; Bellotti and Arias 2001) and its wild relatives (Burbano et al. 2007; Carabalí et al. 2010a, b). Clearly, a valuable opportunity exists for breeding cassava varieties that are highly resistant to pests.

Genetic sources of whitefly resistance in cassava should be of particular interest to breeders and plant molecular biologists. Whiteflies, most notably *Bemisia tabaci* (Gennadius), rank among the most serious agricultural pests globally, and resistance to them is rare in cultivated crops (Bellotti and Arias 2001). Our study identified 19 cassava landraces with high levels of resistance to *A. socialis*. Of these, landrace M Ecu 72 has received the most attention from research (e.g., Bellotti and Arias 2001; Carabalí et al. 2010a, b), being used in crosses with M Bra 12, which resulted in the resistant hybrid Nataima-31 (Arias et al. 2004). In a recent study, M Ecu 72 also showed promising levels of resistance to African populations of *B. tabaci*, which are becoming increasingly serious cassava pests on that continent (Omongo et al. 2012). However, the extent to which resistance to *A. socialis* is associated with resistance to *B. tabaci* is not known, and should be examined.

Accessions with moderate to high levels of green mite resistance are also available in the cassava genebank (Burbano et al. 2007; Bellotti 2008). Resistance to *M. tanajoa* appears to be highest in some accessions of *M. flabellifolia* and *M. peruviana* (Burbano et al. 2007). Previous studies also point to cassava landraces M Bra 12, M Col 1434, and M Ven 125 as promising sources of resistance to *M. tanajoa* (Bellotti and Guerrero 1977; Byrne et al. 1982a, b; Bellotti et al. 1985). Of these three, only M Bra 12 entered our analyses; it classified as having high resistance, along with 32 additional landraces. The extent to which resistance to *M. tanajoa* could also protect cassava from *M. mcgregori* Flechtmann & Baker, recently detected as an invasive pest in Asia (Bellotti et al. 2012), is another key research imperative.

Thrips can be serious dry-season pests of cassava (Schoonhoven and Pena 1976), but farmers seldom report them as such (Bellotti 2008). This may be explained by the high frequency of thrips resistance in cassava cultivars (Bellotti 2008). About half of the cassava genebank holdings at CIAT are resistant to *F. williamsi* (Bellotti 2008). Consistent with this estimate, 46% of landraces that entered our analyses were classified as having high resistance to this pest, supporting the hypothesis that many cassava farmers may be managing thrips, perhaps inadvertently, by growing locally available resistant landraces.

Considerable efforts have been made to identify sources of resistance to several other pest groups. The search for mealybug resistance has been the most thorough. Evaluations of more than 3,000 *Manihot* accessions, both cultivated and wild, discovered only low levels of resistance to *P. herreni*, a key cassava pest in South America (Porter 1988; Burbano et al. 2007). Resistance to sister species *P. manihoti* appears to be similarly rare (Calatayud and Le Rü 2006). However, preliminary studies have reported potential resistance to burrowing bugs, fruit flies, gall midges, grasshoppers, lace bugs, scales, and stemborers (Bellotti and Schoonhoven 1978; Bellotti et al. 1987; Riis et al. 2003b). To our knowledge, these efforts are not part of continuing research programs.

Cassava leaf pubescence and HCN content have been implicated in pest resistance (Schoonhoven 1974; Kasu et al. 1989; Munthau 1992; Bellotti and Riis 1994; Nukenine et al. 2002; Riis et al. 2003a; Mutisya et al. 2013). Consistent with previous studies in cassava, our results support a positive association between pubescence and resistance to thrips, mites, and whiteflies. However, our results failed to support a positive association between a landrace's typical root HCN content and its resistance to our three targeted pests. This finding is consistent with previous studies suggesting HCN may be a resistance factor only for generalist but not for specialist cassava pests (Mutisya et al., 2013; Bellotti and Riis, L., 1994). The implications are promising, as they suggests cassava breeders may safely select against these toxic metabolites in the roots, rendering the crop safer for human consumption, without incurring major tradeoffs on host-plant resistance.

Our research demonstrates useful variation in cassava genotypes for resistance to pest feeding, thus suggesting potential for resistance breeding. Future work should examine covariation patterns in cassava pest resistance to shed light on potential synergies and tradeoffs in defense traits. The ultimate objective of these evaluations would be to provide the knowledge base needed to develop improved cassava cultivars with high resistance to one or more pests.

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References

Arias, B., Bellotti, A.C., Vargas, H., 2004. Nataima-31, a cassava (*Manihot esculenta*) variety resistant to the whitefly, *Aleurotrachelus socialis*, in: Zuñiga, C.S. (Ed.), Sixth International Scientific Meeting of the Cassava Biotechnology Network. CIAT, Cali, Colombia, p. 66.

Bellotti, A.C., Guerrero, J.,1977. Resistencia varietal en yuca contra los ácaros *Tetranychus urticae* y *Mononychellus tanajoa*. Rev. Colomb. Entomol. 3, 87–91.

Bellotti, A.C., Schoonhoven, A., 1978. Mite and insect pests of cassava. Ann. Rev. Entomol. 23,39–67.

Bellotti, A.C., Byrne, D., 1979. Host plant resistance to mite pests of cassava. Recent. Adv. Acarol. 1,13–21.

Bellotti, A.C., Byrne, D., Hershey, C., Vargas, O., Varela, A. 1985. The potential of host plant resistance in cassava for control of mites and mealybugs, in: Cock, J., Reyes, J.A. (Eds.), Cassava: research, production and utilization. CIAT, Cali, Colombia, pp. 417–439.

Bellotti, A.C., Hershey, C., Vargas, O., 1987. Recent advances in resistance to insect and mite pests of cassava, in: Hershey, C.H. (Ed.), Cassava breeding: a multidisciplinary review. CIAT, Cali, Colombia, pp. 117–146.

Bellotti, A.C., Riis, L., 1994. Cassava cyanogenic potential and resistance to pests and diseases, in: Bokanga, M. et al. (Eds.), International Workshop on Cassava Safety. IITA, Ibadan, Nigeria, pp. 141–152.

Bellotti, A.C., Smith, L., Lapointe, S.L., 1999. Recent advances in cassava pest management. Ann. Rev. Entomol. 44, 343–370.

Bellotti, A.C., Arias, B., 2001. Host plant resistance to whiteflies with emphasis on cassava as a case study. Crop Prot. 20, 813–823.

Bellotti, A.C., 2008. Cassava pests and their management, in: Capinera, J.L. (Ed.), Encyclopedia of Entomology. Springer, Berlin, pp. 764–794.

Bellotti, A.C., Herrera Campo, B.V., Hyman, G., 2012. Cassava production and pest management: present and potential threats in a changing environment. Trop. Plant. Biol. 5, 39–72.

Burbano, M.M., Carabalí, A., Montoya-Lerma, J., Bellotti, A.C., 2007. Resistance of *Manihot* species to *Mononychellus tanajoa* (Acariformes), *Aleurotrachelus socialis*, and *Phenacoccus herreni* (Hemiptera). Rev. Colomb. Entomol. 33, 110–115.

Burns, A., Gleadow, R., Cliff J., Zacarias, A., Cavagnaro, T., 2010. Cassava: the drought, war and famine crop in a changing world. Sustainability 2, 3572–3607.

Byrne, D., Guerrero, J., Belloti, A.C., Gracen, V., 1982a. Behavior and development of *Mononychellus tanajoa* (Acari: Tetranychidae) on resistant and susceptible cultivars of cassava. J. Econ. Entomol. 75, 924–927.

Byrne, D., Guerrero, J., Bellotti, A.C., Gracen, V., 1982b. Yield and plant growth responses of *Mononychellus* mite resistant and susceptible cassava cultivars under protected vs. infested conditions. Crop Sci. 22, 486–490.

Calatayud, P.A., Le Rü, B., 2006. Cassava-mealybug interactions. IRD Éditions (Collection Didactiques of the Institut de Recherche pour le Développement). Paris, France.

Carabalí, A., Bellotti, A.C., Montoya-Lerma, J., Fregene, M., 2010a. *Manihot flabellifolia* Pohl, wild source of resistance to the whitefly *Aleurotrachelus socialis* Bondar (Hemiptera: Aleyrodidae). Crop Prot. 29, 34–38.

Carabalí, A., Bellotti, A.C., Montoya-Lerma, J., Fregene, M., 2010b. Resistance to the whitefly, *Aleurotrachelus socialis*, in wild populations of cassava, *Manihot tristis*. J. Insect Sci. 10, 170.

Ceballos, H., Iglesias, C.A., Pérez, J.C., Dixon, A.G., 2004. Cassava breeding: opportunities and challenges. Plant Mol. Biol. 56,503–516.

El-Sharkawy, M.A., 2004. Cassava biology and physiology. Plant Mol. Biol. 56,481–501.

Herren, H., Neuenschwander, P., 1991. Biological control of cassava pests in Africa. Ann. Rev. Entomol. 36, 257–283.

Herrera Campo, B.V., Hyman, G., Bellotti, A.C., 2011. Threats to cassava production: known and potential geographic distribution of four key biotic constraints. Food Secur. 3, 329–345.

Jaramillo, G., 2012. *Manihot* genetic resources at CIAT, in: Ospina, B., Ceballos, H. (Eds.), Cassava in the third millennium. CLAYUCA, Cali, Colombia, pp. 321–341.

Jarvis, A., Ramírez-Villegas, J., Herrera Campo, B.V., Navarro-Racines, C., 2012. Is cassava the answer to African climate change adaptation? Trop. Plant Biol. 5, 9–29.

Kasu, T., Odebiyi, J., Lema, K., 1989. Effects of cassava pubescence on the behaviour, post-embryonic development and reproduction of the cassava mealybug, *Phenacoccus manihoti* Matile-Ferrero (Homoptera: Pseudococcidae). Int. J. Trop. Insect Sci. 10, 123–129.

Lebot, V., 2009. Tropical root and tuber crops: cassava, sweet potato, yams and aroids. CABI, Wallingford, UK.

Munthau, D., 1992. Effect of cassava variety on the biology of *Bemisia afer* (Priesner & Hosny) (Hemiptera: Aleyrodidae). Insect Sci. Applic. 13(3), 459–465.

Mutisya, D.L., Khamala, C.P., El Banhawy, E., Kariuki, C.W., Ragwa, S., 2013. Cassava variety tolerance to spider mite attack in relation to leaf cyanide level. J. Biol. Agric. Healthc. 3, 24–30.

Nukenine, E., Dixon, A., Hassan, A., Zalom, F., 2002. Relationships between leaf trichome characteristics and field resistance to cassava green mite, *Mononychellus tanajoa* (Bondar). Syst. Appl. Acarol. 7, 77–90.

Omongo, C.A., Kawuki, R., Bellotti, A.C., Alicai, T., Baguma, Y., Maruthi, M.N., Bua, A., Colvin, J .,2012. African cassava whitefly, *Bemisia tabaci*, resistance in African and South American cassava genotypes. J. Integr. Agric. 11(2), 327–336.

Parsa, S., Sotelo, G., Cardona, C., 2011. Characterizing herbivore resistance mechanisms: spittlebugs on *Brachiaria* spp. as an example. J. Vis. Exp. (52), e3047.

Porter, R., 1988. Evaluation of germplasm (*Manihot esculenta* Crantz) for resistance to the mealybug (*Phenacoccus herreni* Cox and Williams). Dissertation, Cornell University, Ithaca, NY.

Riis, L., Bellotti, A.C., Bonierbale, M., O'Brien, G.M., 2003a. Cyanogenic potential in cassava and its influence on a generalist insect herbivore *Cyrtomenus bergi* (Hemiptera: Cydnidae). J. Econ. Entomol. 96, 1905–1914.

Riis, L., Bellotti, A.C., Castaño, O., 2003b. In-field damage of high and low cyanogenic cassava due to a generalist insect herbivore *Cyrtomenus bergi* (Hemiptera: Cydnidae). J. Econ. Entomol. 96, 1915–1921.

Roca, W., Chávez, R., Martin, M., Arias, D., Mafla, G., Reyes, R., 1989. *In vitro* methods of germplasm conservation. Genome 31, 813–817.

Sánchez, T., Salcedo, E., Ceballos, H., Dufour, D., Mafla, G., Morante, N., Calle, F., Pérez, J.C., Debouck, D., Jaramillo, G., 2009. Screening of starch quality traits in cassava (*Manihot esculenta* Crantz). Starch - Stärke 61, 12–19.

Schoonhoven, A., 1974. Resistance to thrips damage in cassava. J. Econ. Entomol. 67, 728–730.

Schoonhoven, A., Peña, J., 1976. Estimation of yield losses in cassava following attack from thrips. J. Econ. Entomol. 69, 514–516.

Table 1 Sites for screening pest resistance in the cassava collection held at CIAT.

		No. of trials[a]						Precipitation[c]	Temperature[c] (°C)		
Site	**Department**	**SR**	**PY**	**AY**	**Pest[b]**	**Lat.**	**Long.**	**(mm/year)**	**Mean**	**Max**	**Min**
Aremasain	Guajira	1	1	0	M	11.48	-72.68	656	28.4	34.7	22.2
Chicoral	Tolima	9	0	0	M,T, W	4.22	-74.97	1,331	27.7	34.8	21.9
Ciénaga de Oro	Córdoba	2	0	0	W	8.87	-75.6	1,443	27.6	33.7	22.0
El Carmen	Bolívar	0	2	3	T	7.98	-74.1	2,410	24.1	29.9	18.7
La Libertad	Meta	1	0	0	T	4.03	-73.47	2,883	26.1	33.0	20.6
Media luna	Magdalena	1	2	3	M,T	10.52	-74.52	1,336	28.3	34.7	21.5
Mondomo	Cauca	0	0	1	T	2.88	-76.53	2,228	21.0	27.8	14.8
Palmira	V. del Cauca	14	15	17	M,T,W	3.5	-76.36	1,019	24.0	30.3	18.1
Puerto Gaitán	Meta	0	3	4	M,T	4.6	-71.32	2,218	26.6	33.9	21.5
Quilichao	Cauca	3	0	0	W,T	3.02	-76.47	1,903	23.2	29.8	16.9
Santo Tomás	Atlántico	1	0	0	W	10.73	-74.78	1,020	28.0	33.5	22.0
Valledupar	Cesar	0	3	3	M,T	10.42	-73.58	2,108	20.4	26.7	13.4

[a] SR=single row trial, PY=preliminary yield trial, AY=advanced yield trial
[b] M=green mite, T=thrips, W=whitefly
[c] From the WorldClim climate database (http://www.worldclim.org/) based on geographic coordinates.

Table 2. Damage scales used to evaluate pest resistance in the cassava collection held at CIAT.

Green mite[a]	
0:	No mites or symptoms
1:	Mites on bud leaves, some yellow to white speckling on leaves
2:	Many mites on leaves, moderate speckling of bud leaves and adjacent leaves
3:	Heavy speckling of terminal leaves, slight deformation of bud leaves
4:	Severe deformation of bud leaves, reduction of buds, mites on nearly all leaves, leaves have whitish appearance, some defoliation
5:	Buds greatly reduced or dead, defoliation of upper leaves

Thrips[a]	
0:	No symptoms
1:	Yellow irregular leaf spots only
2:	Leaf spots, light leaf deformation, parts of leaf lobes missing, brown wound tissue in spots on stems and petioles
3:	Severe leaf deformation and distortion, poorly expanded leaves, internodes stunted and covered with brown wound tissue
4:	As above, but with growing points dead, sprouting of lateral buds
5:	Lateral buds also killed, plants greatly stunted, showing “witches’-broom” appearance

Whitefly[b]	
1:	No leaf damage
2:	Young leaves still green but slightly flaccid
3:	Some twisting of young leaves, slight leaf curling
4:	Apical leaves curled and twisted, yellow-green mottled appearance
5:	Same as 4, but with sooty mold and yellowing of leaves
6:	Considerable leaf necrosis and defoliation, sooty mold on central and lower leaves and young stems

[a] From Bellotti et al. 1987

[b] From Bellotti and Arias 2001

Table 3. Estimated pest damage levels for the ten cassava landraces[a] most resistant to each pest, under the highest observed pest pressures.

Pest	Genotype M(*anihot*)	No. of trials	Estimate[b]	95% CI lower	95% CI upper	*t*-ratio[c]	*P*
Green mite	Ven 45A	5	2.99	2.91	3.78	-4.33	0.000
	Bra 49	3	3.06	2.97	3.82	-3.68	0.000
	Pan 70	3	3.27	3.17	4.08	-3.37	0.001
	Cub 74	3	3.53	3.45	4.27	-2.91	0.004
	Col 1522	4	3.53	3.44	3.72	-3.11	0.002
	Col 1719	3	3.57	3.48	4.33	-2.90	0.004
	Cub 46	3	3.57	3.49	4.31	-2.85	0.005
	Col 1804	5	3.58	3.53	4.17	-3.21	0.001
	Cub 10	3	3.59	3.51	4.33	-2.80	0.005
	Ven 23	7	3.59	3.52	3.87	-3.39	0.001
Thrips	Bra 891	3	1.98	1.96	2.00	-2.02	0.044
	Col 2259	3	2.10	2.07	2.13	-1.81	0.070
	Cub 41	3	2.10	2.08	2.12	-1.81	0.071
	Col 2027	3	2.14	2.11	2.16	-1.73	0.083
	Gua 7	5	2.21	2.19	2.23	-1.79	0.073
	Col 2007	5	2.21	2.19	2.24	-1.76	0.079
	Col 1467	4	2.24	2.22	2.27	-1.62	0.105
	Col 2019	10	2.25	2.23	2.27	-1.86	0.063
	Col 2061	11	2.25	2.23	2.28	-1.86	0.063
	Col 113	16	2.26	2.24	2.28	-1.92	0.055
Whitefly	Per 368	3	2.74	2.66	2.82	-2.75	0.006
	Per 317	4	2.81	2.73	2.89	-2.95	0.003
	Ecu 72	7	2.82	2.73	2.92	-3.11	0.002
	Per 334	5	3.25	3.17	3.33	-2.39	0.017
	Per 608	3	3.25	3.17	3.33	-2.10	0.037
	Mex 18	3	3.34	3.26	3.42	-1.96	0.051
	Per 415	3	3.38	3.30	3.46	-1.91	0.058
	Col 1916	3	3.46	3.38	3.54	-1.81	0.072
	Per 273	3	3.46	3.38	3.54	-1.86	0.064
	Mal 20	3	3.50	3.41	3.60	-1.76	0.080

[a] Only landraces evaluated three or more times were considered for analyses.

[b] Lower values indicate greater resistance

[c] Tests whether the true parameter is zero. It is the ratio of the estimate to its standard error and has a Student's t-distribution under the hypothesis, given the usual assumptions about the model.

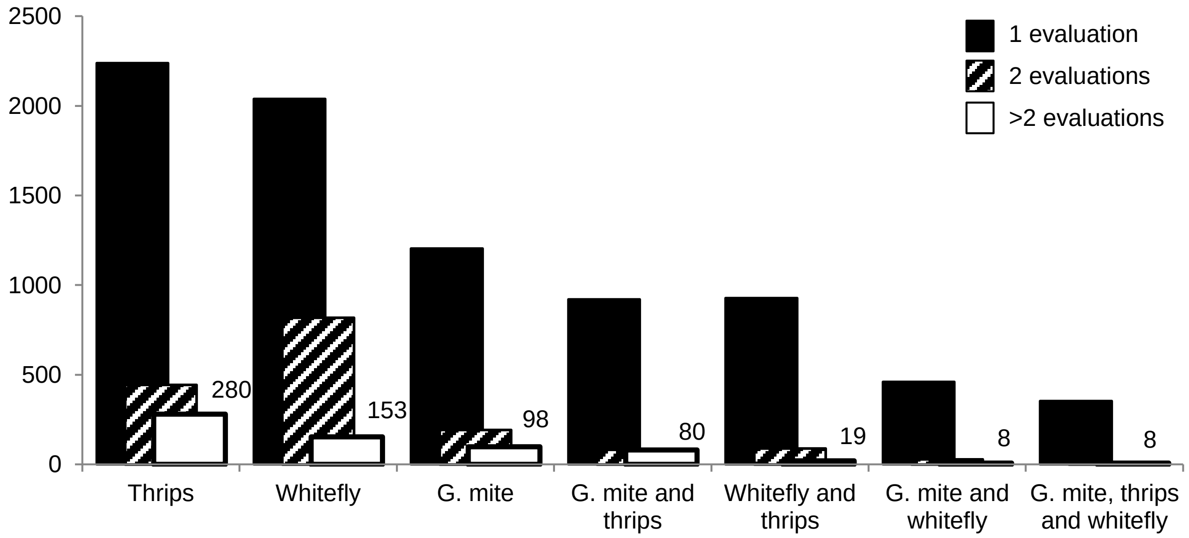

Fig. 1 Number of cassava landraces evaluated for resistance to thrips, whiteflies, and green mites (G. mite). Values in the field indicate the number of landraces evaluated at least three times (white bars) for the pests listed below each set of bars.

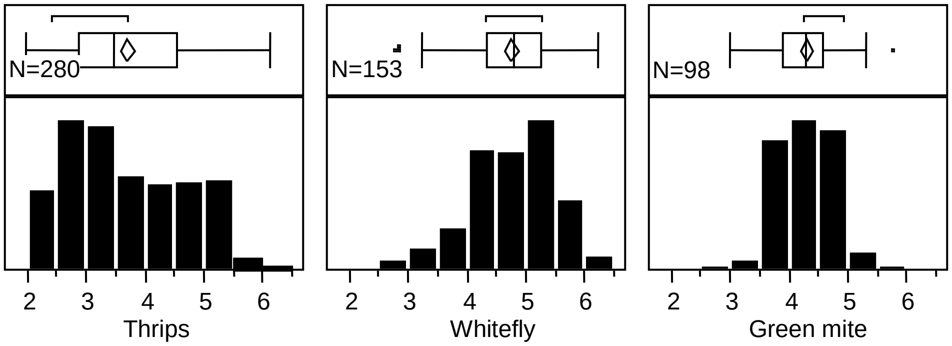

Fig. 2 Frequency distribution and outlier boxplot of estimated damage under the highest observed pest pressure in cassava landraces evaluated three or more times. Resistance increases from right to left.

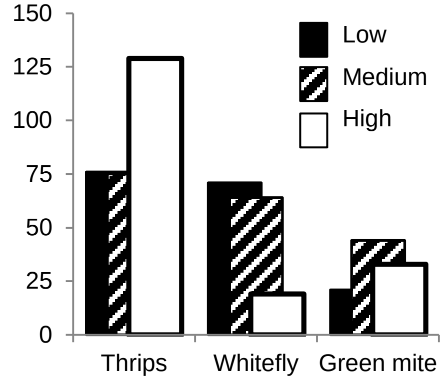

Fig. 3 Number of cassava landraces within three pest resistance categories determined by cluster analyses of their estimated pest damage under the highest observed pest pressures.

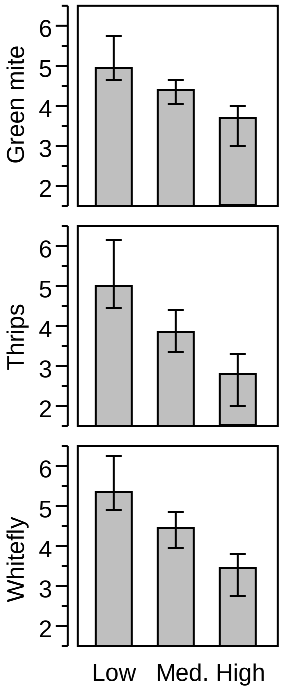

Fig. 4 Estimated pest damage ranges, under the highest observed pest pressures, for the three categories of pest resistance in cassava landraces evaluated three or more times for resistance to thrips, whiteflies, and green mites.

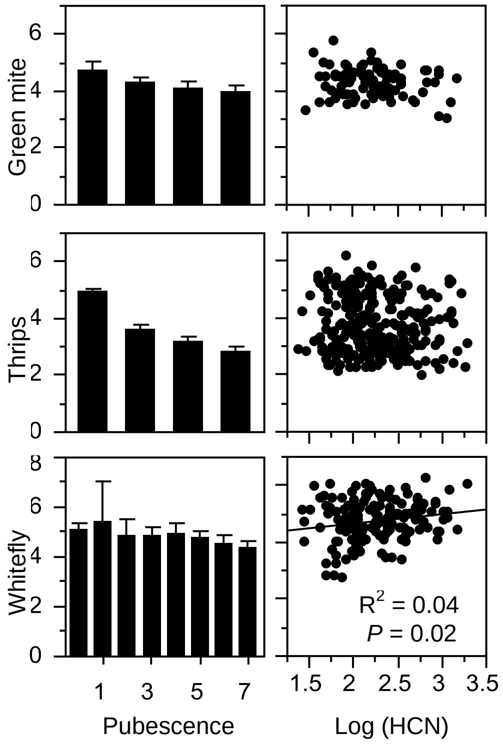

Fig. 5 Scores of estimated pest damage in cassava landraces evaluated three or more times in relation to each landrace’s leaf pubescence and root hydrogen cyanide (HCN) content. Lower values indicate greater resistance. Error bars are based on 95% confidence intervals.

APPENDIX A.

Table 1. Parameter estimates for linear regression model predicting green mite (*Mononychellus tanajoa* (Bondar)) damage as a function of cassava *accession* and *trial*. Only accessions evaluated three or more times were included in the analysis.

Term	Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%
Intercept	2.937	0.053	55.470	<.0001*	2.833	3.041
accession[BRA 3]	1.042	0.433	2.400	0.0167*	0.190	1.894
accession[BRA 12]	-0.268	0.152	-1.760	0.079	-0.568	0.031
accession[BRA 13]	0.609	0.426	1.430	0.154	-0.228	1.446
accession[BRA 15]	-0.688	0.425	-1.620	0.106	-1.523	0.147
accession[BRA 35]	0.423	0.423	1.000	0.317	-0.408	1.254
accession[BRA 41]	0.275	0.426	0.650	0.518	-0.562	1.112
accession[BRA 46]	-0.660	0.370	-1.780	0.075	-1.388	0.068
accession[BRA 49]	-1.225	0.426	-2.880	0.0042*	-2.062	-0.388
accession[BRA 71]	0.136	0.440	0.310	0.757	-0.728	1.001
accession[BRA 73]	0.470	0.440	1.070	0.286	-0.395	1.334
accession[BRA 759]	0.640	0.437	1.460	0.144	-0.219	1.499
accession[BRA 854]	-0.027	0.437	-0.060	0.951	-0.886	0.832
accession[BRA 882]	-0.027	0.437	-0.060	0.951	-0.886	0.832
accession[BRA 891]	-0.360	0.437	-0.820	0.410	-1.219	0.499
accession[BRA 897]	0.306	0.437	0.700	0.484	-0.553	1.165
accession[COL 22]	0.284	0.149	1.900	0.058	-0.009	0.578
accession[COL 72]	0.285	0.330	0.860	0.388	-0.363	0.933
accession[COL 76A]	-0.099	0.300	-0.330	0.740	-0.690	0.491
accession[COL 76B]	-0.548	0.426	-1.290	0.199	-1.385	0.289
accession[COL 113]	-0.599	0.305	-1.960	0.051	-1.199	0.001
accession[COL 304]	-0.127	0.427	-0.300	0.766	-0.968	0.713
accession[COL 638]	0.339	0.423	0.800	0.424	-0.493	1.171
accession[COL 914]	0.568	0.424	1.340	0.181	-0.266	1.402
accession[COL 917]	-0.036	0.368	-0.100	0.922	-0.760	0.688
accession[COL 922]	0.234	0.422	0.550	0.580	-0.595	1.063
accession[COL 948B]	-0.441	0.367	-1.200	0.231	-1.163	0.281
accession[COL 948C]	-0.151	0.370	-0.410	0.683	-0.879	0.576
accession[COL 948D]	-0.378	0.328	-1.150	0.250	-1.023	0.268
accession[COL 949]	-0.448	0.426	-1.050	0.293	-1.285	0.389
accession[COL 976]	1.030	0.366	2.820	0.0051*	0.311	1.750
accession[COL 1112A]	0.718	0.369	1.950	0.052	-0.007	1.444
accession[COL 1413]	-0.279	0.368	-0.760	0.449	-1.001	0.444
accession[COL 1438]	0.137	0.306	0.450	0.655	-0.464	0.738
accession[COL 1468]	0.746	0.155	4.800	<.0001*	0.441	1.052
accession[COL 1503]	0.224	0.422	0.530	0.596	-0.606	1.054
accession[COL 1505]	0.038	0.254	0.150	0.882	-0.462	0.538
accession[COL 1522]	-0.748	0.370	-2.020	0.0438*	-1.475	-0.021
accession[COL 1602]	0.094	0.369	0.250	0.800	-0.631	0.818
accession[COL 1681]	0.709	0.278	2.550	0.0113*	0.162	1.257
accession[COL 1684]	0.433	0.155	2.790	0.0056*	0.127	0.739
accession[COL 1719]	-0.715	0.426	-1.680	0.094	-1.552	0.122

accession[COL 1734]	0.339	0.441	0.770	0.442	-0.527	1.205
accession[COL 1772]	0.595	0.424	1.400	0.161	-0.239	1.429
accession[COL 1786]	-0.037	0.429	-0.090	0.931	-0.882	0.807
accession[COL 1804]	-0.701	0.330	-2.120	0.0344*	-1.350	-0.052
accession[COL 1805]	0.252	0.301	0.840	0.403	-0.339	0.842
accession[COL 1807]	0.023	0.329	0.070	0.945	-0.625	0.671
accession[COL 1818]	-0.510	0.423	-1.210	0.228	-1.341	0.321
accession[COL 1823]	0.168	0.303	0.550	0.581	-0.429	0.764
accession[COL 1826]	0.214	0.301	0.710	0.476	-0.377	0.806
accession[COL 1828A]	0.453	0.421	1.080	0.282	-0.375	1.281
accession[COL 1887]	0.647	0.427	1.520	0.130	-0.192	1.486
accession[COL 1894]	0.525	0.302	1.740	0.083	-0.068	1.119
accession[COL 1942]	0.184	0.368	0.500	0.617	-0.540	0.908
accession[COL 1958]	-0.327	0.366	-0.890	0.372	-1.048	0.393
accession[COL 1964]	0.178	0.368	0.480	0.628	-0.545	0.902
accession[COL 2019]	-0.480	0.427	-1.120	0.262	-1.320	0.360
accession[COL 2059]	-0.480	0.427	-1.120	0.262	-1.320	0.360
accession[COL 2061]	-0.440	0.424	-1.040	0.300	-1.273	0.393
accession[COL 2063]	0.360	0.331	1.090	0.277	-0.291	1.011
accession[COL 2206]	-0.456	0.330	-1.380	0.168	-1.104	0.193
accession[COL 2207]	-0.024	0.280	-0.080	0.933	-0.574	0.527
accession[COL 2215]	0.222	0.241	0.920	0.358	-0.252	0.695
accession[CUB 1]	-0.222	0.423	-0.530	0.600	-1.054	0.610
accession[CUB 5]	-0.372	0.334	-1.110	0.267	-1.029	0.285
accession[CUB 7]	0.428	0.334	1.280	0.201	-0.229	1.085
accession[CUB 10]	-0.692	0.429	-1.610	0.108	-1.536	0.152
accession[CUB 19]	0.475	0.429	1.110	0.269	-0.369	1.318
accession[CUB 31]	-0.192	0.429	-0.450	0.655	-1.036	0.652
accession[CUB 32]	-0.211	0.425	-0.500	0.620	-1.047	0.625
accession[CUB 39]	-0.391	0.426	-0.920	0.359	-1.228	0.446
accession[CUB 42]	1.465	0.370	3.960	<.0001*	0.737	2.193
accession[CUB 46]	-0.711	0.425	-1.670	0.096	-1.547	0.125
accession[CUB 47]	0.141	0.429	0.330	0.742	-0.702	0.985
accession[CUB 50]	0.141	0.429	0.330	0.742	-0.702	0.985
accession[CUB 56]	1.008	0.429	2.350	0.0194*	0.164	1.852
accession[CUB 62]	-0.025	0.429	-0.060	0.953	-0.869	0.818
accession[CUB 63]	0.141	0.429	0.330	0.742	-0.702	0.985
accession[CUB 65]	-0.558	0.426	-1.310	0.191	-1.395	0.279
accession[CUB 74]	-0.753	0.431	-1.740	0.082	-1.601	0.096
accession[DOM 2]	0.617	0.431	1.430	0.153	-0.231	1.465
accession[MAL 1]	0.005	0.427	0.010	0.990	-0.834	0.844
accession[MAL 2]	-0.295	0.427	-0.690	0.490	-1.134	0.544
accession[MAL 3]	-0.061	0.427	-0.140	0.886	-0.900	0.778
accession[MEX 24]	-0.427	0.428	-1.000	0.319	-1.269	0.414
accession[PAN 70]	-1.017	0.423	-2.400	0.0167*	-1.848	-0.185
accession[PAR 1]	-0.186	0.423	-0.440	0.660	-1.017	0.645
accession[PER 242]	0.597	0.426	1.400	0.162	-0.241	1.435
accession[PER 245]	0.278	0.330	0.840	0.399	-0.370	0.927
accession[TAI 1]	0.005	0.427	0.010	0.990	-0.834	0.844
accession[VEN 8]	0.146	0.374	0.390	0.697	-0.590	0.882

accession[VEN 23]	-0.690	0.280	-2.470	0.0141*	-1.240	-0.140
accession[VEN 25]	-0.378	0.280	-1.350	0.178	-0.929	0.173
accession[VEN 45A]	-1.288	0.330	-3.910	0.0001*	-1.936	-0.640
accession[VEN 77]	0.376	0.152	2.470	0.0138*	0.077	0.674
accession[VEN 131]	-0.421	0.425	-0.990	0.322	-1.256	0.413
accession[VEN 156]	0.307	0.424	0.720	0.470	-0.527	1.142
accession[VEN 157]	0.290	0.366	0.790	0.429	-0.430	1.011
trial[GY198007]	0.454	0.184	2.470	0.0139*	0.093	0.815
trial[GY198014]	-0.607	0.208	-2.920	0.0038*	-1.017	-0.198
trial[GY198020]	-1.218	0.247	-4.930	<.0001*	-1.704	-0.732
trial[GY198105]	0.380	0.203	1.870	0.063	-0.020	0.779
trial[GY198115]	1.345	0.165	8.130	<.0001*	1.020	1.670
trial[GY198116]	0.831	0.165	5.030	<.0001*	0.506	1.156
trial[GY198144]	-0.472	0.103	-4.590	<.0001*	-0.674	-0.270
trial[GY198207]	0.029	0.192	0.150	0.878	-0.348	0.407
trial[GY198208]	0.643	0.170	3.770	0.0002*	0.308	0.977
trial[GY198209]	0.955	0.156	6.110	<.0001*	0.648	1.262
trial[GY198213]	-0.687	0.190	-3.610	0.0003*	-1.060	-0.313
trial[GY198214]	0.046	0.149	0.310	0.759	-0.247	0.339
trial[GY198303]	0.839	0.220	3.820	0.0002*	0.407	1.271
trial[GY198304]	-0.661	0.251	-2.630	0.0089*	-1.154	-0.167
trial[GY198305]	0.345	0.179	1.930	0.054	-0.007	0.696
trial[GY198322]	0.371	0.181	2.050	0.0412*	0.015	0.727
trial[GY198345]	0.365	0.195	1.880	0.061	-0.017	0.748
trial[GY198448]	0.035	0.214	0.170	0.869	-0.385	0.456
trial[GY199002]	-0.718	0.251	-2.860	0.0045*	-1.211	-0.224
trial[GY199072]	-1.332	0.273	-4.890	<.0001*	-1.868	-0.796
trial[GY199073]	-0.346	0.273	-1.270	0.205	-0.882	0.190
trial[GY199109]	1.349	0.319	4.230	<.0001*	0.721	1.976
trial[GY199150]	0.349	0.319	1.090	0.275	-0.279	0.976
trial[GY199202]	0.349	0.319	1.090	0.275	-0.279	0.976
trial[GY199233]	-0.651	0.319	-2.040	0.0418*	-1.279	-0.024
trial[GY199278]	-0.769	0.225	-3.410	0.0007*	-1.212	-0.326
trial[GY199362]	0.373	0.197	1.890	0.059	-0.015	0.760
trial[GY199368]	0.326	0.300	1.090	0.278	-0.264	0.916
trial[GY199379]	-1.386	0.186	-7.430	<.0001*	-1.753	-1.019

Table 2. Parameter estimates for linear regression model predicting whitefly (*Aleurotrachellus socialis* Bondar) damage as a function of cassava *accession* and *trial*. Only accessions evaluated three or more times were included in the analysis.

Term	Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%
Intercept	3.013	0.094	32.030	<.0001	2.828	3.198
accession[BRA 29]	0.050	0.531	0.090	0.925	-0.994	1.094
accession[BRA 81]	-1.117	0.531	-2.110	0.036	-2.161	-0.073
accession[BRA 85]	1.027	0.512	2.010	0.046	0.021	2.034
accession[BRA 120]	-0.245	0.509	-0.480	0.631	-1.246	0.756
accession[BRA 153]	0.928	0.510	1.820	0.070	-0.076	1.933
accession[BRA 188]	0.762	0.510	1.490	0.137	-0.242	1.766
accession[BRA 197]	0.755	0.509	1.480	0.139	-0.246	1.756
accession[BRA 198]	0.589	0.509	1.160	0.248	-0.412	1.590
accession[BRA 203]	1.262	0.510	2.470	0.014	0.258	2.266
accession[BRA 208]	0.312	0.563	0.560	0.579	-0.794	1.419
accession[BRA 230]	-0.499	0.521	-0.960	0.339	-1.524	0.527
accession[BRA 237]	0.694	0.512	1.360	0.176	-0.313	1.700
accession[BRA 252]	0.928	0.510	1.820	0.070	-0.076	1.933
accession[BRA 266]	-0.577	0.516	-1.120	0.265	-1.592	0.438
accession[BRA 269]	0.089	0.509	0.170	0.862	-0.912	1.090
accession[BRA 279]	0.089	0.509	0.170	0.862	-0.912	1.090
accession[BRA 281]	0.928	0.510	1.820	0.070	-0.076	1.933
accession[BRA 291]	1.262	0.510	2.470	0.014	0.258	2.266
accession[BRA 303]	0.002	0.454	0.000	0.997	-0.892	0.896
accession[BRA 304]	-0.332	0.521	-0.640	0.525	-1.358	0.693
accession[BRA 329]	-0.028	0.511	-0.050	0.957	-1.034	0.978
accession[BRA 356]	0.287	0.511	0.560	0.575	-0.718	1.292
accession[BRA 364]	1.095	0.510	2.150	0.033	0.091	2.099
accession[BRA 370]	-0.065	0.458	-0.140	0.888	-0.966	0.837
accession[BRA 380]	0.255	0.509	0.500	0.616	-0.746	1.256
accession[BRA 383]	0.025	0.522	0.050	0.962	-1.002	1.052
accession[BRA 384]	0.062	0.416	0.150	0.881	-0.756	0.880
accession[BRA 390]	0.500	0.513	0.970	0.330	-0.509	1.509
accession[BRA 396]	0.255	0.509	0.500	0.616	-0.746	1.256
accession[BRA 398]	0.255	0.509	0.500	0.616	-0.746	1.256
accession[BRA 404]	0.527	0.512	1.030	0.304	-0.479	1.534
accession[BRA 414]	0.589	0.509	1.160	0.248	-0.412	1.590
accession[BRA 442]	-0.372	0.536	-0.690	0.488	-1.427	0.683
accession[BRA 451]	0.428	0.510	0.840	0.402	-0.576	1.433
accession[BRA 482]	-0.411	0.509	-0.810	0.419	-1.412	0.590
accession[BRA 495]	-0.333	0.513	-0.650	0.516	-1.342	0.675

accession[BRA 532]	0.257	0.454	0.570	0.572	-0.637	1.150
accession[BRA 586]	-0.411	0.509	-0.810	0.419	-1.412	0.590
accession[BRA 625]	0.255	0.509	0.500	0.616	-0.746	1.256
accession[BRA 627]	-0.411	0.509	-0.810	0.419	-1.412	0.590
accession[BRA 675]	0.626	0.519	1.210	0.229	-0.395	1.647
accession[BRA 730]	0.763	0.398	1.920	0.056	-0.020	1.545
accession[BRA 769]	1.271	0.524	2.420	0.016	0.240	2.303
accession[BRA 787]	0.262	0.510	0.510	0.609	-0.742	1.266
accession[BRA 798]	-0.078	0.509	-0.150	0.878	-1.079	0.923
accession[BRA 808]	0.333	0.513	0.650	0.516	-0.676	1.342
accession[BRA 833]	-0.333	0.513	-0.650	0.516	-1.342	0.675
accession[BRA 839]	1.138	0.519	2.190	0.029	0.116	2.159
accession[BRA 883]	-0.388	0.516	-0.750	0.453	-1.402	0.627
accession[COL 20]	-0.707	0.515	-1.370	0.171	-1.720	0.307
accession[COL 40]	-0.538	0.446	-1.210	0.229	-1.416	0.340
accession[COL 79]	-0.707	0.515	-1.370	0.171	-1.720	0.307
accession[COL 290]	-0.951	0.511	-1.860	0.063	-1.957	0.054
accession[COL 306]	-0.417	0.517	-0.810	0.421	-1.435	0.601
accession[COL 317]	-0.432	0.531	-0.810	0.416	-1.477	0.612
accession[COL 445B]	-0.658	0.513	-1.280	0.201	-1.668	0.351
accession[COL 1027]	0.500	0.513	0.970	0.330	-0.509	1.509
accession[COL 1036]	-1.000	0.513	-1.950	0.052	-2.009	0.009
accession[COL 1074A]	0.315	0.516	0.610	0.542	-0.700	1.330
accession[COL 1185]	-0.010	0.518	-0.020	0.985	-1.029	1.010
accession[COL 1468]	1.070	0.454	2.360	0.019	0.178	1.962
accession[COL 1505]	0.499	0.381	1.310	0.191	-0.250	1.248
accession[COL 1684]	1.493	0.369	4.050	<.0001	0.767	2.219
accession[COL 1914]	0.046	0.518	0.090	0.929	-0.972	1.064
accession[COL 1916]	-1.285	0.511	-2.510	0.012	-2.290	-0.280
accession[COL 1917]	-0.078	0.509	-0.150	0.878	-1.079	0.923
accession[COL 1950]	0.089	0.509	0.170	0.862	-0.912	1.090
accession[COL 2019]	-0.173	0.571	-0.300	0.762	-1.296	0.950
accession[COL 2025]	-0.258	0.532	-0.490	0.628	-1.305	0.789
accession[COL 2173]	1.170	0.578	2.030	0.044	0.034	2.306
accession[COL 2215]	-0.268	0.480	-0.560	0.576	-1.212	0.675
accession[COL 2246]	0.747	0.529	1.410	0.159	-0.294	1.788
accession[COL 2493]	-0.010	0.518	-0.020	0.985	-1.029	1.010
accession[ECU 23]	0.536	0.516	1.040	0.300	-0.480	1.552
accession[ECU 53]	-0.254	0.514	-0.490	0.622	-1.264	0.757
accession[ECU 70]	1.168	0.510	2.290	0.023	0.165	2.172
accession[ECU 72]	-1.923	0.383	-5.020	<.0001	-2.677	-1.170
accession[ECU 115]	0.002	0.510	0.000	0.997	-1.002	1.005
accession[ECU 199]	-0.665	0.510	-1.300	0.193	-1.669	0.339

accession[GUA 69]	0.262	0.510	0.510	0.609	-0.742	1.266
accession[GUA 92]	0.262	0.510	0.510	0.609	-0.742	1.266
accession[HMC 1]	0.382	0.533	0.720	0.474	-0.667	1.430
accession[IND 39]	0.634	0.570	1.110	0.266	-0.486	1.755
accession[MAL 20]	-1.245	0.509	-2.450	0.015	-2.246	-0.244
accession[MAL 25]	-0.405	0.510	-0.790	0.428	-1.409	0.599
accession[MEX 1]	0.428	0.510	0.840	0.402	-0.576	1.433
accession[MEX 5]	0.537	0.444	1.210	0.227	-0.336	1.411
accession[MEX 10]	0.412	0.444	0.930	0.353	-0.461	1.286
accession[MEX 11]	-0.245	0.509	-0.480	0.631	-1.246	0.756
accession[MEX 18]	-1.405	0.510	-2.750	0.006	-2.409	-0.401
accession[MEX 22]	-1.072	0.510	-2.100	0.037	-2.076	-0.067
accession[MEX 86]	-0.053	0.510	-0.100	0.918	-1.056	0.950
accession[MEX 91]	-0.738	0.510	-1.450	0.149	-1.742	0.266
accession[MEX 95]	0.298	0.449	0.660	0.507	-0.585	1.181
accession[MEX 98]	0.095	0.510	0.190	0.852	-0.909	1.099
accession[MEX 105]	-0.738	0.510	-1.450	0.149	-1.742	0.266
accession[MEX 108]	-0.553	0.510	-1.080	0.279	-1.556	0.450
accession[PAN 51]	0.358	0.522	0.690	0.493	-0.669	1.385
accession[PAN 135]	-0.092	0.545	-0.170	0.866	-1.164	0.980
accession[PAN 136]	-0.072	0.510	-0.140	0.889	-1.076	0.933
accession[PER 178]	-0.806	0.512	-1.580	0.116	-1.813	0.200
accession[PER 183]	0.889	0.525	1.690	0.091	-0.143	1.922
accession[PER 185]	-0.694	0.516	-1.340	0.180	-1.709	0.322
accession[PER 187]	1.168	0.510	2.290	0.023	0.165	2.172
accession[PER 204]	0.753	0.514	1.460	0.144	-0.259	1.765
accession[PER 209]	-0.084	0.519	-0.160	0.872	-1.106	0.938
accession[PER 212]	0.365	0.514	0.710	0.478	-0.646	1.377
accession[PER 232]	-0.737	0.520	-1.420	0.157	-1.760	0.285
accession[PER 238]	-0.105	0.513	-0.200	0.838	-1.113	0.903
accession[PER 243]	0.768	0.522	1.470	0.142	-0.258	1.795
accession[PER 244]	1.062	0.513	2.070	0.039	0.053	2.070
accession[PER 260]	-0.738	0.510	-1.450	0.149	-1.742	0.266
accession[PER 273]	-1.284	0.531	-2.420	0.016	-2.327	-0.240
accession[PER 274]	-0.368	0.516	-0.710	0.476	-1.383	0.646
accession[PER 277]	0.168	0.510	0.330	0.742	-0.835	1.172
accession[PER 296]	0.245	0.513	0.480	0.634	-0.764	1.254
accession[PER 312]	0.846	0.514	1.650	0.100	-0.164	1.857
accession[PER 315]	-0.135	0.514	-0.260	0.794	-1.146	0.877
accession[PER 316]	-0.404	0.520	-0.780	0.438	-1.426	0.619
accession[PER 317]	-1.938	0.455	-4.260	<.0001	-2.834	-1.042
accession[PER 325]	0.920	0.514	1.790	0.075	-0.092	1.932
accession[PER 326]	-1.194	0.516	-2.310	0.021	-2.209	-0.178

accession[PER 327]	-0.142	0.514	-0.280	0.783	-1.152	0.869
accession[PER 332]	-0.165	0.510	-0.320	0.747	-1.169	0.839
accession[PER 334]	-1.498	0.421	-3.560	0.000	-2.326	-0.671
accession[PER 335]	-0.998	0.510	-1.960	0.051	-2.002	0.005
accession[PER 352]	0.513	0.514	1.000	0.319	-0.497	1.523
accession[PER 368]	-2.004	0.522	-3.840	0.000	-3.030	-0.978
accession[PER 369]	0.753	0.514	1.460	0.144	-0.259	1.765
accession[PER 371]	0.680	0.453	1.500	0.135	-0.212	1.571
accession[PER 372]	-1.221	0.517	-2.360	0.019	-2.238	-0.205
accession[PER 380]	-0.332	0.510	-0.650	0.516	-1.335	0.672
accession[PER 415]	-1.367	0.513	-2.660	0.008	-2.376	-0.358
accession[PER 420]	-0.319	0.445	-0.720	0.474	-1.194	0.556
accession[PER 421]	-1.028	0.449	-2.290	0.023	-1.911	-0.146
accession[PER 423]	-0.220	0.510	-0.430	0.667	-1.223	0.783
accession[PER 425]	0.420	0.514	0.820	0.415	-0.592	1.432
accession[PER 428]	0.168	0.510	0.330	0.742	-0.835	1.172
accession[PER 444]	0.562	0.513	1.100	0.274	-0.447	1.570
accession[PER 446]	-0.498	0.510	-0.980	0.330	-1.502	0.505
accession[PER 455]	0.335	0.510	0.660	0.512	-0.669	1.339
accession[PER 474]	0.595	0.510	1.170	0.245	-0.409	1.599
accession[PER 480]	0.762	0.510	1.490	0.137	-0.242	1.766
accession[PER 481]	0.762	0.510	1.490	0.137	-0.242	1.766
accession[PER 594]	0.168	0.510	0.330	0.742	-0.835	1.172
accession[PER 600]	0.246	0.514	0.480	0.632	-0.764	1.257
accession[PER 608]	-1.498	0.510	-2.940	0.004	-2.502	-0.495
accession[TAI 8]	0.436	0.451	0.970	0.334	-0.451	1.323
accession[VEN 19]	-0.738	0.510	-1.450	0.149	-1.742	0.266
accession[VEN 25]	0.604	0.441	1.370	0.172	-0.263	1.472
accession[VEN 77]	-0.262	0.519	-0.510	0.614	-1.284	0.759
accession[VEN 133]	-1.072	0.510	-2.100	0.037	-2.076	-0.067
accession[VEN 139]	-0.238	0.510	-0.470	0.641	-1.242	0.766
trial[CE200220]	-0.036	0.136	-0.270	0.790	-0.303	0.231
trial[CH199201]	0.210	0.231	0.910	0.364	-0.244	0.663
trial[CH199302]	-0.111	0.172	-0.640	0.520	-0.449	0.227
trial[CH199303]	1.000	0.282	3.540	0.001	0.445	1.554
trial[CH199604]	-1.871	0.144	-12.970	<.0001	-2.155	-1.587
trial[CH199626]	0.084	0.196	0.430	0.668	-0.301	0.469
trial[CH199706]	0.489	0.730	0.670	0.504	-0.948	1.926
trial[CH199707]	1.432	0.695	2.060	0.040	0.065	2.798
trial[CO200113]	-2.336	0.376	-6.210	<.0001	-3.077	-1.596
trial[CO200221]	-2.329	0.564	-4.130	<.0001	-3.439	-1.219
trial[CP199605]	1.731	0.315	5.500	<.0001	1.112	2.351
trial[CP199708]	1.603	0.171	9.390	<.0001	1.268	1.939

trial[CP199709]	1.370	0.246	5.570	<.0001	0.886	1.853
trial[CP200011]	1.027	0.190	5.390	<.0001	0.653	1.402
trial[NA200222]	0.249	0.296	0.840	0.400	-0.333	0.831
trial[NA200425]	0.309	0.531	0.580	0.561	-0.735	1.352
trial[QU200223]	-1.040	0.276	-3.770	0.000	-1.583	-0.498
trial[QU200527]	0.557	0.280	1.990	0.048	0.006	1.109

Table 3. Parameter estimates for linear regression model predicting thrips (*Frankliniella williamsi* Hood) damage as a function of cassava *accession* and *trial*. Only accessions evaluated three or more times were included in the analysis.

Term	Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%
Intercept	2.563	0.028	91.190	<.0001	2.508	2.618
accession[ARG 7]	-0.657	0.363	-1.810	0.070	-1.369	0.054
accession[ARG 13]	-0.750	0.255	-2.940	0.003	-1.250	-0.250
accession[BRA 5]	0.572	0.251	2.280	0.023	0.080	1.064
accession[BRA 12]	-1.167	0.090	-12.920	<.0001	-1.344	-0.990
accession[BRA 13]	-0.032	0.307	-0.100	0.917	-0.634	0.570
accession[BRA 15]	-0.933	0.305	-3.060	0.002	-1.531	-0.335
accession[BRA 22]	1.445	0.353	4.090	<.0001	0.752	2.138
accession[BRA 29]	-0.880	0.306	-2.880	0.004	-1.480	-0.281
accession[BRA 31]	0.092	0.351	0.260	0.793	-0.597	0.781
accession[BRA 33]	-1.241	0.351	-3.530	0.000	-1.931	-0.552
accession[BRA 35]	-0.476	0.252	-1.890	0.059	-0.970	0.018
accession[BRA 41]	-0.532	0.307	-1.730	0.083	-1.134	0.070
accession[BRA 46]	-0.063	0.251	-0.250	0.800	-0.555	0.428
accession[BRA 49]	0.218	0.307	0.710	0.477	-0.384	0.820
accession[BRA 67]	0.358	0.275	1.300	0.193	-0.181	0.898
accession[BRA 71]	0.367	0.233	1.580	0.115	-0.089	0.823
accession[BRA 73]	1.503	0.217	6.920	<.0001	1.076	1.929
accession[BRA 89]	-0.597	0.306	-1.950	0.051	-1.198	0.003
accession[BRA 91]	1.653	0.306	5.400	<.0001	1.052	2.253
accession[BRA 97]	-0.030	0.360	-0.080	0.933	-0.736	0.675
accession[BRA 98]	0.460	0.352	1.310	0.192	-0.231	1.151
accession[BRA 106]	0.127	0.352	0.360	0.719	-0.564	0.818
accession[BRA 107]	0.460	0.352	1.310	0.192	-0.231	1.151
accession[BRA 108]	-0.097	0.306	-0.320	0.750	-0.698	0.503
accession[BRA 113]	-0.494	0.251	-1.970	0.049	-0.986	-0.001
accession[BRA 125]	1.554	0.232	6.700	<.0001	1.099	2.009
accession[BRA 135]	1.460	0.352	4.140	<.0001	0.769	2.151
accession[BRA 142]	0.127	0.352	0.360	0.719	-0.564	0.818
accession[BRA 155]	1.653	0.306	5.400	<.0001	1.052	2.253
accession[BRA 158]	1.663	0.218	7.640	<.0001	1.236	2.090
accession[BRA 164]	-0.206	0.352	-0.590	0.558	-0.898	0.485
accession[BRA 165]	-0.444	0.356	-1.250	0.212	-1.143	0.254
accession[BRA 171]	1.460	0.352	4.140	<.0001	0.769	2.151
accession[BRA 174]	-0.020	0.219	-0.090	0.928	-0.450	0.410
accession[BRA 176]	1.514	0.274	5.520	<.0001	0.976	2.053
accession[BRA 191]	-1.188	0.198	-6.000	<.0001	-1.577	-0.800

accession[BRA 200]	-1.165	0.362	-3.220	0.001	-1.875	-0.455
accession[BRA 201]	0.335	0.313	1.070	0.285	-0.280	0.949
accession[BRA 235]	-1.241	0.363	-3.420	0.001	-1.953	-0.529
accession[BRA 253]	1.169	0.362	3.230	0.001	0.459	1.879
accession[BRA 255]	-0.465	0.362	-1.280	0.199	-1.175	0.245
accession[BRA 312]	1.802	0.357	5.050	<.0001	1.102	2.503
accession[BRA 325]	1.298	0.353	3.680	0.000	0.606	1.990
accession[BRA 348]	0.402	0.362	1.110	0.267	-0.308	1.112
accession[BRA 359]	-1.369	0.353	-3.880	0.000	-2.060	-0.677
accession[BRA 383]	-1.331	0.198	-6.720	<.0001	-1.720	-0.943
accession[BRA 390]	-1.344	0.279	-4.810	<.0001	-1.892	-0.796
accession[BRA 403]	-0.792	0.355	-2.230	0.026	-1.489	-0.096
accession[BRA 405]	-0.792	0.355	-2.230	0.026	-1.489	-0.096
accession[BRA 416]	0.208	0.355	0.590	0.559	-0.489	0.904
accession[BRA 491]	-0.531	0.357	-1.490	0.137	-1.232	0.169
accession[BRA 514]	0.965	0.353	2.740	0.006	0.273	1.657
accession[BRA 589]	-0.526	0.276	-1.910	0.057	-1.068	0.015
accession[BRA 769]	-0.569	0.312	-1.820	0.068	-1.182	0.043
accession[BRA 839]	-1.192	0.352	-3.390	0.001	-1.882	-0.502
accession[BRA 878]	-0.763	0.363	-2.100	0.036	-1.475	-0.050
accession[BRA 881]	-1.263	0.363	-3.480	0.001	-1.975	-0.550
accession[BRA 882]	-1.263	0.363	-3.480	0.001	-1.975	-0.550
accession[BRA 885]	-0.696	0.363	-1.920	0.055	-1.408	0.016
accession[BRA 887]	-1.029	0.363	-2.840	0.005	-1.742	-0.317
accession[BRA 890]	0.471	0.363	1.300	0.195	-0.242	1.183
accession[BRA 891]	-1.696	0.363	-4.670	<.0001	-2.408	-0.984
accession[CHN 1]	-0.641	0.311	-2.060	0.040	-1.251	-0.030
accession[COL 22]	-0.870	0.089	-9.730	<.0001	-1.045	-0.695
accession[COL 72]	-0.837	0.161	-5.210	<.0001	-1.152	-0.522
accession[COL 113]	-1.419	0.156	-9.090	<.0001	-1.725	-1.112
accession[COL 638]	-0.662	0.187	-3.540	0.000	-1.029	-0.295
accession[COL 862]	-0.783	0.357	-2.190	0.028	-1.483	-0.083
accession[COL 917]	-1.162	0.352	-3.300	0.001	-1.853	-0.471
accession[COL 948B]	-1.162	0.352	-3.300	0.001	-1.853	-0.471
accession[COL 948C]	-0.855	0.255	-3.350	0.001	-1.356	-0.354
accession[COL 948D]	-1.182	0.306	-3.870	0.000	-1.782	-0.582
accession[COL 976]	-0.495	0.352	-1.400	0.160	-1.186	0.196
accession[COL 1413]	-0.827	0.305	-2.710	0.007	-1.424	-0.229
accession[COL 1438]	-0.259	0.161	-1.610	0.109	-0.575	0.057
accession[COL 1467]	-1.432	0.306	-4.680	<.0001	-2.032	-0.832
accession[COL 1468]	1.036	0.088	11.800	<.0001	0.864	1.209
accession[COL 1486]	-0.808	0.351	-2.300	0.021	-1.497	-0.120
accession[COL 1495]	-0.206	0.352	-0.590	0.558	-0.898	0.485

accession[COL 1503]	0.759	0.351	2.160	0.031	0.069	1.448
accession[COL 1505]	-0.272	0.152	-1.790	0.074	-0.571	0.026
accession[COL 1522]	-0.852	0.188	-4.520	<.0001	-1.222	-0.483
accession[COL 1525]	-0.540	0.352	-1.530	0.126	-1.231	0.151
accession[COL 1681]	1.365	0.275	4.970	<.0001	0.826	1.904
accession[COL 1684]	1.112	0.089	12.440	<.0001	0.937	1.288
accession[COL 1693]	1.042	0.310	3.360	0.001	0.434	1.650
accession[COL 1740]	-0.495	0.352	-1.400	0.160	-1.186	0.196
accession[COL 1772]	0.904	0.232	3.890	0.000	0.448	1.360
accession[COL 1777]	1.077	0.356	3.030	0.003	0.379	1.776
accession[COL 1805]	-0.432	0.306	-1.410	0.158	-1.032	0.168
accession[COL 1818]	-0.706	0.232	-3.050	0.002	-1.161	-0.251
accession[COL 1823]	-0.510	0.167	-3.060	0.002	-0.837	-0.183
accession[COL 1826]	0.028	0.253	0.110	0.911	-0.467	0.524
accession[COL 1828A]	-0.182	0.306	-0.600	0.551	-0.782	0.418
accession[COL 1887]	1.239	0.274	4.520	<.0001	0.702	1.777
accession[COL 1894]	1.138	0.172	6.610	<.0001	0.801	1.476
accession[COL 1900]	1.538	0.250	6.150	<.0001	1.047	2.028
accession[COL 1901]	1.127	0.352	3.200	0.001	0.436	1.818
accession[COL 1908]	0.127	0.352	0.360	0.719	-0.564	0.818
accession[COL 1914]	0.745	0.306	2.440	0.015	0.145	1.344
accession[COL 1916]	0.570	0.186	3.060	0.002	0.204	0.935
accession[COL 1940]	-0.630	0.306	-2.060	0.039	-1.230	-0.031
accession[COL 1942]	0.204	0.250	0.820	0.414	-0.286	0.695
accession[COL 1958]	-1.395	0.273	-5.110	<.0001	-1.931	-0.859
accession[COL 1964]	-0.839	0.166	-5.060	<.0001	-1.165	-0.514
accession[COL 1984]	1.153	0.306	3.770	0.000	0.552	1.753
accession[COL 2006]	-0.682	0.306	-2.230	0.026	-1.282	-0.082
accession[COL 2007]	-1.463	0.277	-5.290	<.0001	-2.006	-0.920
accession[COL 2014]	-1.110	0.311	-3.570	0.000	-1.719	-0.500
accession[COL 2016]	-0.983	0.233	-4.220	<.0001	-1.440	-0.526
accession[COL 2017]	-1.227	0.218	-5.630	<.0001	-1.654	-0.799
accession[COL 2019]	-1.428	0.196	-7.300	<.0001	-1.812	-1.044
accession[COL 2024]	0.021	0.306	0.070	0.946	-0.580	0.621
accession[COL 2027]	-1.540	0.352	-4.370	<.0001	-2.231	-0.849
accession[COL 2032]	-0.053	0.179	-0.300	0.767	-0.405	0.299
accession[COL 2033]	-1.222	0.308	-3.970	<.0001	-1.826	-0.618
accession[COL 2047]	0.653	0.306	2.130	0.033	0.052	1.253
accession[COL 2054]	-0.348	0.196	-1.780	0.076	-0.732	0.036
accession[COL 2057]	-0.418	0.196	-2.130	0.033	-0.802	-0.034
accession[COL 2058]	-1.376	0.216	-6.360	<.0001	-1.800	-0.952
accession[COL 2059]	-0.947	0.206	-4.590	<.0001	-1.352	-0.543
accession[COL 2060]	-0.605	0.250	-2.420	0.016	-1.095	-0.116

accession[COL 2061]	-1.421	0.187	-7.580	<.0001	-1.789	-1.053
accession[COL 2063]	-0.595	0.233	-2.550	0.011	-1.053	-0.137
accession[COL 2066]	1.570	0.352	4.460	<.0001	0.879	2.261
accession[COL 2084]	1.460	0.352	4.140	<.0001	0.769	2.151
accession[COL 2087]	1.142	0.254	4.500	<.0001	0.644	1.640
accession[COL 2088]	0.075	0.277	0.270	0.787	-0.468	0.618
accession[COL 2089]	1.495	0.250	5.970	<.0001	1.004	1.986
accession[COL 2099]	-0.097	0.306	-0.320	0.750	-0.698	0.503
accession[COL 2100]	1.653	0.306	5.400	<.0001	1.052	2.253
accession[COL 2110]	1.746	0.354	4.930	<.0001	1.051	2.441
accession[COL 2111]	0.837	0.310	2.700	0.007	0.229	1.445
accession[COL 2116]	1.460	0.352	4.140	<.0001	0.769	2.151
accession[COL 2125]	1.460	0.352	4.140	<.0001	0.769	2.151
accession[COL 2129]	1.158	0.275	4.210	<.0001	0.619	1.698
accession[COL 2133]	1.158	0.275	4.210	<.0001	0.619	1.698
accession[COL 2145]	0.958	0.275	3.480	0.001	0.419	1.498
accession[COL 2147]	2.127	0.352	6.040	<.0001	1.436	2.818
accession[COL 2148]	1.127	0.352	3.200	0.001	0.436	1.818
accession[COL 2157]	1.419	0.351	4.040	<.0001	0.730	2.108
accession[COL 2163]	1.153	0.306	3.770	0.000	0.552	1.753
accession[COL 2171]	1.403	0.306	4.580	<.0001	0.802	2.003
accession[COL 2172]	2.460	0.352	6.980	<.0001	1.769	3.151
accession[COL 2184]	1.903	0.306	6.220	<.0001	1.302	2.503
accession[COL 2204]	-0.871	0.352	-2.480	0.013	-1.560	-0.181
accession[COL 2205]	-0.537	0.352	-1.530	0.127	-1.227	0.152
accession[COL 2206]	-0.964	0.305	-3.160	0.002	-1.563	-0.366
accession[COL 2207]	-0.511	0.273	-1.870	0.062	-1.046	0.025
accession[COL 2209]	0.351	0.277	1.270	0.205	-0.191	0.894
accession[COL 2210]	1.758	0.275	6.390	<.0001	1.219	2.298
accession[COL 2212]	1.174	0.275	4.260	<.0001	0.634	1.714
accession[COL 2215]	-0.425	0.168	-2.530	0.011	-0.754	-0.096
accession[COL 2216]	0.425	0.235	1.810	0.071	-0.036	0.886
accession[COL 2237]	-0.975	0.281	-3.470	0.001	-1.525	-0.424
accession[COL 2253]	-0.342	0.280	-1.220	0.221	-0.890	0.206
accession[COL 2256]	-0.395	0.357	-1.110	0.269	-1.096	0.306
accession[COL 2259]	-1.577	0.365	-4.320	<.0001	-2.293	-0.862
accession[CUB 1]	-0.808	0.351	-2.300	0.021	-1.497	-0.120
accession[CUB 5]	0.096	0.218	0.440	0.660	-0.332	0.523
accession[CUB 7]	0.084	0.233	0.360	0.719	-0.374	0.542
accession[CUB 10]	-0.953	0.275	-3.470	0.001	-1.492	-0.414
accession[CUB 14]	0.092	0.351	0.260	0.793	-0.597	0.781
accession[CUB 18]	1.024	0.206	4.970	<.0001	0.619	1.428
accession[CUB 19]	-0.953	0.275	-3.470	0.001	-1.492	-0.414

accession[CUB 22]	-0.575	0.351	-1.640	0.102	-1.264	0.115
accession[CUB 26]	1.127	0.352	3.200	0.001	0.436	1.818
accession[CUB 29]	-0.475	0.351	-1.350	0.176	-1.163	0.213
accession[CUB 31]	-0.953	0.275	-3.470	0.001	-1.492	-0.414
accession[CUB 32]	-0.386	0.155	-2.490	0.013	-0.689	-0.082
accession[CUB 34]	0.092	0.351	0.260	0.793	-0.597	0.781
accession[CUB 36]	0.995	0.250	3.970	<.0001	0.504	1.486
accession[CUB 37]	0.878	0.275	3.200	0.001	0.339	1.417
accession[CUB 39]	0.610	0.274	2.230	0.026	0.073	1.147
accession[CUB 40]	-0.702	0.353	-1.990	0.047	-1.394	-0.010
accession[CUB 41]	-1.575	0.351	-4.480	<.0001	-2.264	-0.885
accession[CUB 42]	-0.172	0.232	-0.740	0.459	-0.626	0.283
accession[CUB 43]	1.355	0.218	6.200	<.0001	0.926	1.783
accession[CUB 46]	-0.406	0.178	-2.280	0.023	-0.754	-0.057
accession[CUB 47]	-0.864	0.232	-3.720	0.000	-1.320	-0.408
accession[CUB 48]	0.759	0.351	2.160	0.031	0.069	1.448
accession[CUB 49]	-0.400	0.187	-2.140	0.033	-0.767	-0.033
accession[CUB 50]	-0.689	0.308	-2.240	0.025	-1.292	-0.086
accession[CUB 51]	-0.966	0.249	-3.880	0.000	-1.455	-0.478
accession[CUB 53]	-1.055	0.307	-3.440	0.001	-1.657	-0.453
accession[CUB 54]	0.460	0.352	1.310	0.192	-0.231	1.151
accession[CUB 56]	1.146	0.206	5.580	<.0001	0.743	1.549
accession[CUB 58]	-0.136	0.304	-0.450	0.654	-0.733	0.460
accession[CUB 60]	-0.133	0.356	-0.370	0.708	-0.831	0.565
accession[CUB 62]	-0.553	0.275	-2.010	0.045	-1.092	-0.014
accession[CUB 63]	-0.439	0.308	-1.430	0.154	-1.042	0.164
accession[CUB 64]	1.314	0.274	4.790	<.0001	0.776	1.853
accession[CUB 65]	-0.827	0.274	-3.020	0.003	-1.365	-0.289
accession[CUB 66]	0.810	0.305	2.650	0.008	0.211	1.409
accession[CUB 74]	-0.803	0.147	-5.460	<.0001	-1.091	-0.514
accession[DOM 2]	-0.985	0.275	-3.580	0.000	-1.524	-0.445
accession[DOM 4]	-1.136	0.304	-3.740	0.000	-1.733	-0.540
accession[DOM 5]	-0.482	0.357	-1.350	0.177	-1.182	0.218
accession[ECU 72]	-1.184	0.252	-4.690	<.0001	-1.679	-0.689
accession[ECU 82]	0.831	0.273	3.040	0.002	0.296	1.367
accession[ECU 160]	-0.495	0.352	-1.400	0.160	-1.186	0.196
accession[GUA 7]	-1.468	0.280	-5.240	<.0001	-2.017	-0.918
accession[GUA 36]	-0.991	0.363	-2.730	0.006	-1.702	-0.279
accession[GUA 43]	-0.989	0.356	-2.780	0.006	-1.687	-0.291
accession[GUA 72]	0.009	0.363	0.030	0.980	-0.702	0.721
accession[GUA 74]	-0.719	0.359	-2.000	0.045	-1.422	-0.015
accession[GUA 78]	-0.989	0.356	-2.780	0.006	-1.687	-0.291
accession[IND 8]	1.690	0.279	6.050	<.0001	1.142	2.238

accession[IND 19]	1.568	0.314	4.990	<.0001	0.952	2.184
accession[IND 23]	-0.611	0.359	-1.700	0.089	-1.316	0.094
accession[IND 25]	0.436	0.362	1.200	0.229	-0.274	1.146
accession[IND 27]	1.661	0.355	4.670	<.0001	0.964	2.358
accession[IND 33]	-0.672	0.355	-1.890	0.059	-1.370	0.025
accession[IND 39]	-0.662	0.260	-2.550	0.011	-1.172	-0.152
accession[IND 44]	2.068	0.314	6.580	<.0001	1.452	2.684
accession[IND 45]	0.314	0.361	0.870	0.384	-0.394	1.022
accession[IND 46]	0.326	0.313	1.040	0.298	-0.289	0.941
accession[MAL 1]	1.359	0.232	5.860	<.0001	0.904	1.815
accession[MAL 2]	0.007	0.156	0.050	0.962	-0.298	0.313
accession[MAL 3]	1.817	0.251	7.240	<.0001	1.325	2.309
accession[MAL 6]	0.086	0.362	0.240	0.811	-0.623	0.795
accession[MAL 9]	-0.686	0.361	-1.900	0.058	-1.394	0.022
accession[MAL 13]	0.530	0.311	1.710	0.088	-0.079	1.140
accession[MAL 22]	0.158	0.362	0.440	0.662	-0.552	0.868
accession[MAL 23]	-1.033	0.318	-3.250	0.001	-1.655	-0.410
accession[MAL 24]	0.030	0.311	0.100	0.922	-0.579	0.640
accession[MAL 27]	0.011	0.356	0.030	0.976	-0.687	0.709
accession[MAL 29]	1.661	0.355	4.670	<.0001	0.964	2.358
accession[MAL 34]	-0.278	0.359	-0.770	0.439	-0.983	0.427
accession[MAL 35]	0.328	0.355	0.920	0.357	-0.370	1.025
accession[MAL 36]	0.818	0.314	2.600	0.009	0.202	1.434
accession[MAL 37]	-1.255	0.283	-4.440	<.0001	-1.809	-0.700
accession[MAL 40]	0.314	0.361	0.870	0.384	-0.394	1.022
accession[MAL 48]	-1.208	0.257	-4.700	<.0001	-1.713	-0.704
accession[MAL 54]	-1.353	0.361	-3.750	0.000	-2.060	-0.645
accession[MAL 61]	-1.247	0.362	-3.450	0.001	-1.956	-0.538
accession[MAL 63]	0.994	0.355	2.800	0.005	0.297	1.692
accession[MEX 19]	-0.908	0.351	-2.580	0.010	-1.597	-0.219
accession[MEX 25]	-1.162	0.352	-3.300	0.001	-1.853	-0.471
accession[MEX 59]	-0.328	0.221	-1.490	0.138	-0.762	0.105
accession[MEX 83]	-1.253	0.366	-3.430	0.001	-1.970	-0.536
accession[NGA 1]	1.473	0.355	4.150	<.0001	0.776	2.169
accession[NGA 2]	1.370	0.309	4.430	<.0001	0.764	1.976
accession[PAN 51]	-0.399	0.195	-2.050	0.041	-0.782	-0.016
accession[PAN 70]	-0.896	0.197	-4.550	<.0001	-1.282	-0.510
accession[PAN 90]	1.075	0.354	3.040	0.002	0.381	1.769
accession[PAN 97]	0.529	0.310	1.710	0.088	-0.078	1.137
accession[PAN 101]	0.370	0.306	1.210	0.227	-0.230	0.969
accession[PAR 1]	-0.136	0.304	-0.450	0.654	-0.733	0.460
accession[PAR 4]	-0.734	0.304	-2.410	0.016	-1.331	-0.137
accession[PAR 101]	-1.128	0.311	-3.620	0.000	-1.739	-0.518

accession[PAR 105]	-0.923	0.361	-2.550	0.011	-1.632	-0.214
accession[PER 192]	-0.433	0.351	-1.230	0.218	-1.122	0.257
accession[PER 239]	-0.758	0.354	-2.140	0.032	-1.453	-0.064
accession[PER 241]	0.692	0.250	2.770	0.006	0.201	1.182
accession[PER 242]	0.356	0.218	1.630	0.103	-0.072	0.784
accession[PER 245]	0.692	0.180	3.850	0.000	0.339	1.044
accession[PER 253]	-0.258	0.354	-0.730	0.465	-0.953	0.436
accession[PER 278]	1.631	0.353	4.630	<.0001	0.940	2.323
accession[PER 281]	1.158	0.273	4.240	<.0001	0.622	1.694
accession[PER 283]	1.599	0.205	7.790	<.0001	1.196	2.001
accession[PER 293]	1.298	0.353	3.680	0.000	0.606	1.990
accession[PER 296]	1.893	0.354	5.350	<.0001	1.200	2.587
accession[PER 297]	0.495	0.250	1.980	0.048	0.004	0.986
accession[PER 318]	1.460	0.352	4.140	<.0001	0.769	2.151
accession[PER 328]	1.141	0.352	3.240	0.001	0.451	1.831
accession[TAI 1]	-0.266	0.218	-1.220	0.224	-0.693	0.162
accession[TAI 2]	-1.378	0.311	-4.430	<.0001	-1.989	-0.768
accession[TAI 3]	-0.790	0.358	-2.210	0.028	-1.492	-0.088
accession[TAI 5]	0.914	0.284	3.220	0.001	0.358	1.471
accession[TAI 8]	-0.270	0.239	-1.130	0.259	-0.738	0.199
accession[VEN 23]	0.548	0.218	2.510	0.012	0.120	0.975
accession[VEN 25]	0.476	0.156	3.050	0.002	0.170	0.782
accession[VEN 45A]	0.290	0.273	1.060	0.289	-0.246	0.826
accession[VEN 77]	0.575	0.089	6.490	<.0001	0.402	0.749
accession[VEN 131]	-0.495	0.352	-1.400	0.160	-1.186	0.196
accession[VEN 156]	0.097	0.196	0.490	0.623	-0.288	0.481
accession[VEN 157]	-0.536	0.353	-1.520	0.129	-1.229	0.156
accession[VEN 168]	-0.495	0.352	-1.400	0.160	-1.186	0.196
accession[VEN 185]	-0.652	0.186	-3.500	0.001	-1.018	-0.286
trial[GY198020]	0.470	0.178	2.630	0.009	0.120	0.820
trial[GY198034]	0.521	0.231	2.250	0.024	0.068	0.974
trial[GY198105]	-0.159	0.158	-1.000	0.315	-0.469	0.151
trial[GY198106]	-0.265	0.125	-2.110	0.035	-0.511	-0.019
trial[GY198121]	0.557	0.072	7.770	<.0001	0.416	0.697
trial[GY198144]	-0.206	0.070	-2.930	0.004	-0.344	-0.068
trial[GY198216]	0.681	0.091	7.480	<.0001	0.502	0.859
trial[GY198230]	0.445	0.079	5.630	<.0001	0.290	0.600
trial[GY198241]	0.589	0.138	4.280	<.0001	0.319	0.859
trial[GY198303]	1.112	0.084	13.250	<.0001	0.948	1.277
trial[GY198305]	0.883	0.141	6.270	<.0001	0.606	1.159
trial[GY198321]	-0.866	0.083	-10.490	<.0001	-1.028	-0.704
trial[GY198333]	0.093	0.187	0.500	0.619	-0.274	0.459
trial[GY198334]	0.064	0.137	0.470	0.641	-0.205	0.333

trial[GY198345]	0.850	0.148	5.750	<.0001	0.560	1.140
trial[GY198405]	-0.668	0.199	-3.360	0.001	-1.058	-0.278
trial[GY198409]	-0.793	0.098	-8.060	<.0001	-0.985	-0.600
trial[GY198410]	-0.160	0.151	-1.060	0.289	-0.457	0.136
trial[GY198424]	0.128	0.199	0.640	0.521	-0.263	0.518
trial[GY198505]	0.255	0.144	1.770	0.076	-0.027	0.538
trial[GY198506]	0.794	0.108	7.360	<.0001	0.582	1.005
trial[GY198513]	-0.752	0.200	-3.760	0.000	-1.145	-0.360
trial[GY198514]	-0.374	0.127	-2.950	0.003	-0.623	-0.125
trial[GY198535]	-0.316	0.057	-5.540	<.0001	-0.428	-0.204
trial[GY198614]	-0.254	0.169	-1.510	0.132	-0.586	0.077
trial[GY198615]	-0.151	0.129	-1.170	0.243	-0.404	0.102
trial[GY198627]	-0.295	0.183	-1.610	0.107	-0.653	0.064
trial[GY198628]	-0.047	0.122	-0.390	0.699	-0.286	0.192
trial[GY198643]	0.494	0.118	4.200	<.0001	0.263	0.724
trial[GY198647]	-0.306	0.123	-2.480	0.013	-0.548	-0.064
trial[GY198712]	-0.127	0.148	-0.860	0.392	-0.418	0.164
trial[GY198733]	0.402	0.189	2.130	0.034	0.031	0.773
trial[GY198750]	-0.018	0.179	-0.100	0.921	-0.370	0.334
trial[GY198806]	-0.738	0.198	-3.730	0.000	-1.126	-0.349
trial[GY198807]	-0.525	0.123	-4.270	<.0001	-0.767	-0.284
trial[GY198808]	-0.311	0.143	-2.180	0.030	-0.592	-0.031
trial[GY198839]	-0.054	0.100	-0.540	0.590	-0.251	0.143
trial[GY198912]	0.124	0.129	0.960	0.339	-0.130	0.377
trial[GY198913]	0.075	0.139	0.540	0.593	-0.199	0.348
trial[GY198914]	-0.021	0.172	-0.120	0.902	-0.359	0.317
trial[GY198954]	-0.125	0.238	-0.530	0.599	-0.591	0.341
trial[GY199002]	0.422	0.185	2.280	0.023	0.058	0.785
trial[GY199010]	-0.701	0.151	-4.650	<.0001	-0.997	-0.405
trial[GY199029]	-0.841	0.106	-7.920	<.0001	-1.049	-0.632
trial[GY199032]	-0.281	0.179	-1.570	0.116	-0.631	0.070
trial[GY199072]	-1.195	0.229	-5.210	<.0001	-1.644	-0.745
trial[GY199109]	0.107	0.152	0.700	0.482	-0.191	0.405
trial[GY199150]	0.390	0.237	1.650	0.100	-0.075	0.856
trial[GY199202]	0.299	0.269	1.110	0.266	-0.229	0.827
trial[GY199233]	0.137	0.201	0.680	0.494	-0.256	0.531
trial[GY199234]	-0.434	0.165	-2.620	0.009	-0.759	-0.110
trial[GY199283]	0.258	0.067	3.820	0.000	0.126	0.390
trial[GY199402]	0.021	0.244	0.090	0.930	-0.457	0.500