Insect Resistance in Sweetpotato Plant Introductions

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Abstract. One hundred U.S. sweetpotato [Ipomoea batatas (L.) Lam.] plant introductions (PIs) and four control cultivars were screened for insect injury in 1993. Of the least injured by insects, 56 and 31 were tested again in 1994 and 1995, respectively. Among control cultivars, the most highly resistant was ‘Regal’ (moderately resistant), followed by ‘Beauregard’ (susceptible), ‘Centennial’ (susceptible), and ‘Jewel’ (susceptible). Stem and root injury by the sweetpotato weevil (SPW) [Cylas formicarius elegantulus (Summers)] and root injury by the wireworm (Conoderus sp.–Diabrotica sp. (cucumber beetle)–Systena sp. (flea beetle) (WDS) complex] were measured. SPW stem injury was less severe (P ≤ 0.05) in 1994 and 1995 in PIs 508523, 531116, and 564107 than in control cultivars. PIs 508523 and 531116 also suffered less SPW root injury than did ‘Regal’. In the six PIs with least SPW root injury, PIs 538354, 564149, 508523, 538286, 531116, and 564103, 70% to 85% of the roots were not injured compared with 36% in ‘Regal’ and 6% in ‘Jewel’. SPW root injury scores (0 = no injury; 5 = severe injury) in those PIs averaged 0.5 vs. 2.3 for ‘Regal’. Only in PI 538286 was WDS injury to roots less than in ‘Regal’ over 2 years. However, eight additional accessions suffered less WDS injury than ‘Regal’ in 1995 and four of those were among the six with least SPW injury. The lower levels of combined insect injury found in these four PIs (compared to ‘Regal’) show that PIs have potential use for increasing insect resistance in sweetpotato improvement programs.

Adult SPW feed on above- and below-ground plant parts and oviposit in stems and storage roots. Larvae feed and develop inside the root and render it inedible. Insecticidal control is difficult because of inaccessibility of immature stages of the insect within the root. In addition, the host range of the SPW, including sweetpotatoes and related Ipomoea sp., and possible movement of the weevil in commercial sweetpotatoes contribute to the difficulty of control. Low levels of SPW resistance have been found and can be increased by breeding (Hahn and Leuschner, 1981; Mullen et al., 1985). Hahn and Leuschner (1981) initiated a program in 1971 to breed for resistance to the African SPW (Cylas puncticollis Boh.). Resistance to stem and root injury was increased by selection, and a highly significant correlation of 0.74 between root and shoot injury was observed.

Mullen et al. (1985) evaluated breeding lines developed for increased insect resistance, and found severity of root injury by the SPW to the susceptible check ‘Centennial’ over 2.5 times as great as injury to the breeding line released as ‘Regal’ (Jones et al., 1985).

Other soil-inhabiting insects, including those in the wireworm (Conoderus sp.–Diabrotica sp. (cucumber beetle)–Systena sp. (flea beetle) (WDS) complex are also injurious to sweetpotato storage roots and are serious sweetpotato pests in the United States. Injury caused by larvae of the WDS complex is primarily to the surface of storage roots, affecting their appearance and grade. Insecticidal control is often ineffective in preventing injury by these insects and considerable losses are often incurred. The cultivars Resisto, Southern Delite, and Regal (Jones et al., 1987) were reported to have resistance to WDS injury. An integrated pest management (IPM) program would be the most effective insect control measure for SPW and the WDS complex, but increased host-plant resistance to these insects is needed for such a program to be effective.

We began a breeding program for insect resistance in 1990, using the most advanced plant materials from the aforementioned programs, and determined that a moderate rate of gain in resistance levels is possible through intermaturing and selection (Thompson et al., 1994). Although these materials are useful, additional insect-resistant sweetpotato sources must be identified so that the genetic base and range of resistance levels can be increased more rapidly. The objective of this research was to identify additional sources of resistance to the SPW and the WDS insect complex by evaluating germplasm from the U.S. Plant Introduction collection.

Table 1. U.S. sweetpotato plant introductions (PI) evaluated for insect resistance and their countries of origin.

| PI          | Country of origin |
|-------------|-------------------|
| 304088      | Mexico            |
| 315342      | Philippines       |
| 318858      | Peru              |
| 399163      | Guatemala         |
| 439749      | Mexico            |
| 508506      | Japan             |
| 508508      | Japan             |
| 508509      | Japan             |
| 508510      | Korea             |
| 508513      | Brazil            |
| 508514      | PR China          |
| 508515      | PR China          |
| 508517      | PR China          |
| 508519      | PR China          |
| 508520      | PR China          |
| 508521      | PR China          |
| 508523      | Guam              |
| 508525      | Puerto Rico       |
| 508528      | United States     |
| 508529      | Puerto Rico       |
| 508530      | Venezuela         |
| 508531      | Venezuela         |
| 531096      | Guatemala         |
| 531107      | Peru              |
| 531116      | Nigeria           |

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Table 1. Continued.

| PI     | Country of origin    |
|--------|----------------------|
| 531118 | Peru                 |
| 531121 | Peru                 |
| 531122 | United States        |
| 531123 | Peru                 |
| 531124 | Peru                 |
| 531125 | Peru                 |
| 531130 | Peru                 |
| 531133 | Peru                 |
| 531134 | Costa Rica           |
| 531135 | Costa Rica           |
| 531136 | Mexico               |
| 531137 | Mexico               |
| 531139 | Costa Rica           |
| 531140 | Costa Rica           |
| 531141 | Taiwan               |
| 531144 | Taiwan               |
| 531145 | Taiwan               |
| 531146 | Taiwan               |
| 531147 | Taiwan               |
| 531149 | Peru                 |
| 531150 | Peru                 |
| 531152 | Peru                 |
| 531154 | Puerto Rico          |
| 531156 | Puerto Rico          |
| 531159 | Peru                 |
| 531166 | Peru                 |
| 531168 | Peru                 |
| 531169 | Peru                 |
| 564106 | Peru                 |
| 564107 | Peru                 |
| 564108 | Peru                 |
| 564109 | Peru                 |
| 564110 | Peru                 |
| 564111 | Peru                 |
| 564112 | Peru                 |
| 564113 | Peru                 |
| 564114 | Peru                 |
| 564115 | Peru                 |
| 564116 | Taiwan               |
| 564117 | Taiwan               |
| 564118 | Taiwan               |
| 564119 | Taiwan               |
| 564120 | Nigeria              |
| 564121 | Tonga                |
| 564122 | Tonga                |
| 564123 | Western Samoa        |
| 564124 | Western Samoa        |

Materials and Methods

**Plant materials.** One hundred sweetpotato plant introductions (PIs) of diverse origins were selected based on availability from the U.S. germplasm collection at Experiment, Ga. (Table 1). These and four control cultivars were field evaluated for SPW and WDS injury in preliminary trials in 1993 (data not presented). Based on the percentage of uninjured roots, severity of insect injury, and a minimum storage root yield, 56 of those PIs were tested in 1994. Thirty-one of those PIs were tested again in 1995, along with 25 PIs not previously tested (Tables 2 and 3). Results from accessions included in 1994 and 1995 are reported here. The controls and their previously determined resistance levels to SPW, based on the percentage of weevil-infested roots and crown injury (Mullen et al., 1985), and to the WDS complex, based on percentage of injury-free roots and a severity index (Jones et al., 1987), were ‘Centennial’ (susceptible), ‘Jewel’ (susceptible), and ‘Regal’ (moderately susceptible/resistant).

**Insects.** During the winter before each evaluation, SPW were collected from storage roots infested the previous season in producers’ fields at four to six Mississippi locations. They were cultured on storage roots in 1.1-L glass jars. Wild SPW were increased separately by location of origin over three generations, after which 20 males were placed with 20 females from a different location in each of a series of jars. The insects were allowed to oviposit in roots for a 7-d period. Adults that emerged from those roots for a period of 7-d were used for field infestation. Therefore, adult SPW 1 to 7 d old were used for infestation. Evaluation of WDS injury was based on naturally occurring insects.

**Resistance evaluation.** Field evaluations were conducted at the South Mississippi Branch Experiment Station in Beaumont, Miss., which is in a SPW-infested area, but SPW weevil populations were low. Injury appeared to be exclusively from applied weevils, since few weevils were caught in pheromone traps before releases were made at the beginning of sweetpotato storage root enlargement. Consistently high WDS injury was observed on sweetpotatoes grown in previous years at the test site and naturally occurring insect levels were considered adequate for evaluations.

Plant introductions were received as plants derived from nodal explants in Dec. 1992 and increased by stem cuttings for field evaluations in 1993. Most plants were propagated from storage roots in 1994 and 1995, with a few clones being increased from plants maintained in a greenhouse. On 10–13 May 1994 and 17–19 May 1995, plants were transplanted to five plant field plots in a randomized block design with eight replications. Plants were spaced 36 cm apart in rows 1 m apart.

Field infestation of SPW was repeated for two infestation times in 1994 and 1995. The SPW increase was timed to coincide with storage root enlargement based on 1993 results. The first infestation was completed when all accessions had started storage root enlargement (64 d after transplanting in both years) as determined by examining plants outside the experimental area. Therefore, storage roots of all entries were available for infestation at the time of SPW release. Seven days after first SPW emergence from roots used for increase (15 July and 15 Aug. 1994, and 20 July and 10 Aug. 1995) roots were placed in containers with open bottoms and suspended from rods 1.3 m high in sweetpotato plots. Containers with closed tops were suspended above the plots to prevent storage root destruction by contact with soil, rainwater, and rodents. One container was centrally placed between every two plots. Since SPW were released the same distance from all PIs, distance from the source should not have influenced differences in injury among PIs. Nearly equal quantities (by weight) of roots were placed in each container. Random samples of containerized roots were monitored to determine numbers of SPW. Based on those observations, an average of 16 SPW per plant was applied.

On 26–28 Oct. 1994, and again on 14–16 Nov. 1995, stems were cut 25 cm above the soil surface and plants with storage roots attached were dug and placed in bags. Stem and storage root WDS and SPW injury evaluations were completed 31 Oct. to 10 Nov. 1994 and 27 Nov. to 6 Dec. 1995. Measurements taken were root numbers, root weights, numbers of WDS, and SPW-infested roots, SPW-infested stems, and scores for WDS root injury and SPW stem and storage root injury. SPW stem injury was scored by observing injury from the point of first storage root attachment to a point 10 cm above the soil surface. Stem injury ratings were: 0 = no injury, 1 = 1% to 20% injured tissue, 2 = 21% to 40%, 3 = 41% to 60%, 4 = 61% to 80%, and 5 = 81% to 100%, and root injury ratings were: 0 = no injury, 1 = larval tunnels 0.1–5 mm deep and 0.1% to 6% internal tissue injury, 2 = tunnels 5.1–10 mm deep and 6.1% to 12% tissue injury, 3 =
The percentage of uninjured roots and lower root injury scores than did ‘Regal’. Differ-
ences among the eight PI/cultivars were apparent, but there were exceptions (Table 2). For example, of the three PIs with least stem injury, 531116 and 508523 had greater percentage of uninjured roots and lower root injury scores in both years than did ‘Regal’, but root injury in PI 564107 was similar to that in ‘Regal’. The lack of precise agreement was reflected in the partial correlation coefficient between stem injury and root injury of 0.19 (P ≤ 0.01), which was lower than the 0.74 reported by Hahn and Leuschner (1981). A strong relationship was observed between SPW and WDS injury levels. Partial correlations in percentage of and in injury scores were 0.46 and 0.68 (P ≤ 0.01), respectively.

Results and Discussion

Stem injury by SPW was more severe in 1995 than in 1994 (Table 2). The mean stem injury scores over all entries were 2.6 and 3.9 in 1994 and 1995, respectively. The PI × year interaction for stem injury was significant. The reported resistance levels of the four control cultivars to root injury were not observed for stem injury, since few differences among the controls were found (Table 2). The PIs 508523, 531116, and 564107 had lower stem injury scores in both years than did the controls (P ≤ 0.05).

The percentage of roots not injured by SPW was greater in the 10 least-injured PIs than in ‘Regal’ and greater in 24 PIs than in the susceptible control ‘Centennial’ (Table 2). Fifty-eight percent to 85% of the roots of those 10 PIs were not injured, compared with 36% in ‘Regal’ and 12% in ‘Centennial’. Of the 10 PIs with less root injury than ‘Regal’, eight had lower SPW injury scores than did ‘Regal’ (Table 2). The 24 PIs with fewer injured roots than ‘Centennial’ also had lower injury scores than did ‘Centennial’. The root injury scores ranged from 0.3 to 1.0 in the eight least-injured PIs vs. 2.3 in ‘Regal’ and 3.4 in ‘Centennial’. Therefore, severity of root injury was 2.3 to 7.7 times greater in ‘Regal’ than in the least-injured PIs. The PI × year interaction for percentage of SPW injury and injury score was nonsignificant at P ≤ 0.05. The low genotype × environment interactions for SPW root injury in this study differed from the report by Thompson et al. (1994), who estimated genetic variances of a breeding population and found that genotype × environment interactions were significant.

The only PI that had a greater percentage of WDS-uninjured roots than ‘Regal’ in both years was PI 538286 (P ≤ 0.05) (Table 3). PIs 538354 and 564107 had a greater percentage of WDS-uninjured roots than ‘Regal’ in 1994, but they did not differ in 1995. Several of the highest ranking PIs that did not differ from ‘Regal’ in 1994 had greater percentage of uninjured roots in 1995 than ‘Regal’. Differences among PIs and ‘Regal’ in WDS injury scores paralleled those for percentage of uninjured roots. Scores for ‘Regal’ were higher than those for PI 538286 in both years, for PIs 524107 and 531116 in 1994, and for several PIs in 1995. Most of those in the last category also had greater percentage of uninjured roots than did ‘Regal’ in 1995.

Of the six PIs with lower SPW injury levels than ‘Regal’, PIs 564103, 538286, and 508523 were also among the six injured least by WDS and differed from ‘Regal’ in percentage of WDS-uninjured roots and severity of root injury in 1995.

The reported resistance levels of the four con-

Literature Cited

Chalfant, R.B., R.K. Jansson, D.R. Seal, and J.M. Chalfant. 1990. Ecology and management of sweetpotato insects. Annu. Rev. Entomol. 35:157–180.

Hahn, S.K. and K. Leuschner. 1981. Resistance of sweetpotato cultivars to African sweetpotato weevil. Crop Sci. 21:499–503.

Jones, A., P.D. Dukes, J.M. Schalk, M.G. Hamilton, M.A. Mullen, R.A. Baumgardner, D.R. Patterson, and T.E. Boswell. 1985. ‘Regal’ sweetpotato. HortScience 20:781–782.

Jones, A., J.M. Schalk, and P.D. Dukes. 1987. Control of soil insect injury by resistance in sweetpotato. J. Amer. Soc. Hort. Sci. 112:195–197.

Mullen, M.A., A. Jones, D.R. Patterson, and T.E.
| PIO | 1994 Noninjured roots (%) | 1995 Noninjured roots (%) | 1994 Injury score | 1995 Injury score |
|-----|--------------------------|--------------------------|-----------------|-----------------|
| 538286 | 51 a<sup>1</sup> | 47 c–e | 0.4 a | 0.9 b–f |
| 564107 | 50 ab | 01 | 0.5 ab | 2.1 j–n |
| 538354 | 43 a–c | 29 d–i | 0.9 a–d | 1.2 c–i |
| 564103 | 33 b–d | 100 a | 1.1 b–f | 0.0 a |
| 508523 | 32 cd | 41 c–f | 0.9 a–d | 1.1 b–h |
| 564149 | 27 c–e | 26 e–k | 1.2 c–g | 1.4 e–j |
| 531116 | 26 c–e | 10 i–l | 0.7 a–c | 1.3 d–i |
| 508525 | 20 d–f | 14 h–l | 1.5 d–j | 1.7 g–k |
| 564106 | 19 d–g | 29 d–i | 1.0 a–e | 1.5 e–j |
| 564115 | 17 d–h | 50 cd | 1.2 c–g | 1.5 e–j |
| Regal | 16 d–h | 16 g–l | 1.5 d–j | 1.9 i–m |
| 531130 | 14 e–h | 50 cd | 1.5 d–j | 1.1 b–h |
| 564138 | 14 e–h | 20 f–l | 1.3 c–h | 1.5 e–j |
| 564145 | 13 e–h | 16 g–l | 1.5 d–j | 1.7 g–k |
| 531147 | 13 e–h | 75 b | 1.6 e–j | 0.4 ab |
| 531122 | 12 e–h | 34 c–h | 1.7 f–j | 0.9 h–f |
| 315342 | 11 e–h | 52 c | 1.4 d–i | 0.6 a–d |
| 304088 | 11 e–h | 01 | 1.9 h–l | 1.0 b–g |
| 531135 | 10 e–h | 10 i–l | 1.2 c–g | 1.3 d–i |
| 538345 | 7 f–h | 27 e–j | 1.6 e–j | 1.1 b–h |
| 508511 | 7 f–h | 6 j–l | 1.5 d–j | 1.6 f–j |
| 531123 | 7 f–h | 13 h–l | 1.4 d–i | 1.4 e–j |
| 531146 | 6 f–h | 11 | 1.7 f–j | 2.7 n |
| 531159 | 6 f–h | 22 f–l | 1.4 d–i | 1.8 h–l |
| 531136 | 5 f–h | 15 h–l | 2.4 k–n | 2.6 mn |
| Jewel | 4 f–h | 11 | 2.5 l–n | 2.8 n |
| 564133 | 2 gh | 5 j–l | 2.0 i–m | 1.7 g–k |
| 531118 | 1 h | 18 g–l | 1.3 c–h | 1.4 e–j |
| Beauregard | 1 h | 6 j–l | 2.6 mn | 2.5 l–n |
| 531133 | 0 h | 51 cd | 1.0 a–e | 0.8 b–e |
| 531168 | 0 h | 50 cd | 2.1 j–n | 0.5 a–c |
| 531139 | 0 h | 16 g–l | 1.8 g–k | 1.4 e–j |
| 531149 | 0 h | 38 c–g | 1.8 g–k | 0.6 a–d |
| Centennial | 0 h | 4 kl | 2.7 n | 2.5 l–n |
| 531134 | 0 h | 19 f–l | 1.7 f–j | 2.4 k–n |

*Based on number of feeding scars; 0 = no scars, 1 = one to five scars, 2 = six to 10 scars, 3 = 11 to 15 scars, and 4 = more than 15 scars.

<sup>1</sup>Mean separation within columns by LSD (<i>P</i> ≤ 0.05).

*Interaction significant at <i>P</i> ≤ 0.05.

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Boswell, 1985. Resistance in sweetpotatoes to the sweetpotato weevil. J. Entomol. Sci. 20:345–350.

Sorensen, K.A. 1984. Impact of the sweetpotato weevil in the Southeast. In: M.A. Mullen and K.A. Sorensen (eds.). Sweetpotato weevil—Proc. of a workshop, sweetpotato weevil. Entomol. Soc. Amer. Southeastern Branch. Dept. Entomol., North Carolina State Univ., Raleigh.

Thompson, P.G., J.C. Schneider, and B. Graves. 1994. Genetic variance component and heritability estimates of freedom from weevil injury to sweetpotato. J. Amer. Soc. Hort. Sci. 199:620–623.

Wolfe, G.W. 1991. The origin and dispersal of the pest species of <i>Cylas</i> with a key to the pest species groups of the world, p. 13–43. In: R.K. Jansson and K.V. Raman (eds.). Sweetpotato pest management: A global perspective. Westview Press, Boulder, Colo.