



Host Plant Resistance in Solanum Germplasm

**An Appraisal of Resistance
to Colorado Potato Beetle,
Potato Leafhopper and
Potato Flea Beetle**

Kathy L. Flanders and Edward B. Radcliffe

UNIVERSITY OF MINNESOTA

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HOST PLANT RESISTANCE IN *SOLANUM* GERMPLASM

An Appraisal of Resistance to Colorado Potato Beetle, Potato Leafhopper, and Potato Flea Beetle

Kathy L. Flanders and Edward B. Radcliffe

ABSTRACT

Exotic potato, *Solanum* spp., plant introductions from the Inter-Regional Potato Introduction Project (IR-1) were evaluated in replicated field trials for resistance to Colorado potato beetle, *Leptinotarsa decemlineata* (Say); potato leafhopper, *Empoasca fabae* (Harris); and potato flea beetle, *Epitrix cucumeris* (Harris).

Data for each insect were subjected to k-means

cluster analysis to group plant introductions into resistance classes. Colorado potato beetle resistance was identified in 80 plant introductions in 13 species or species hybrids. Potato leafhopper resistance was identified in 116 plant introductions in 49 species or species hybrids. Potato flea beetle resistance was identified in 102 plant introductions in 33 species or species hybrids.

INTRODUCTION

Exotic potato (*Solanum*) species have long been recognized for their potential as sources of host plant resistance to insect and disease pests. Attempts to breed potatoes with insect resistance began in Europe prior to World War II (Ross 1966). Exotic potato species have been used as parent stock to incorporate a variety of useful characteristics into present day potato cultivars. To date, 13 species of exotic potatoes have been incorporated into the commercial cultivars developed in the United States (Plaisted and Hoopes 1989, Rowe 1969).

Potato germplasm is maintained in nine major potato genebanks around the world. The Inter-Regional Potato Introduction Project in Sturgeon Bay, Wisconsin, is the sole genebank for wild and cultivated potatoes in the United States (Hanneman 1989). While considerable work has

been done on evaluating the germplasm held by the Inter-Regional Potato Introduction Project for resistance to insect and disease pests, including Colorado potato beetle, potato leafhopper and potato flea beetle (Hanneman and Bamberg 1986, Radcliffe et al. 1981), the resistance status of many plant introductions is unknown.

The present study was undertaken as part of a U.S. Department of Agriculture—Agricultural Research Service funded initiative to identify potential sources of pest resistance in accessions maintained by the Inter-Regional Potato Introduction Project. During 1983-1986, we evaluated 1,470 plant introductions for resistance to Colorado potato beetle, *Leptinotarsa decemlineata* (Say), potato leafhopper, *Empoasca fabae* (Harris), and/or potato flea beetle, *Epitrix cucumeris* (Harris).

Reported here are results for each plant introduction. Resistance to these insect pests, to green peach aphid, *Myzus persicae* (Sulzer), and to potato aphid, *Macrosiphum euphorbiae*

(Thomas), are discussed for each potato species with respect to evolutionary relationships, plant defense mechanisms and ecogeographic association in Flanders et al. (1992).

MATERIALS AND METHODS

The experiments reported in this monograph were conducted from 1983-1986. All accessions evaluated were obtained as true seed from the Inter-Regional Potato Introduction Project, courtesy of Dr. Robert Hanneman, Jr. Identities of plant introductions were verified by John Hawkes (University of Birmingham, Birmingham, U.K.) or John Bamberg (Potato Introduction Station, Sturgeon Bay, Wisconsin).

One species included in our trials has not yet been described in publication. It is referred to in the text and tables as: *S. n. sp.*, represented by PI 473209 and PI 473210.

Plant introductions were planted in the greenhouse in late April in randomized plots. Each plot consisted of potato seed planted in six 185 cm³ peat pots. Peat pots containing more than three seedlings were thinned to two or three seedlings per peat pot. Extra seedlings from a given plant introduction were used to fill peat pots where seeds did not germinate. Seed germination varied between plant introductions, so the density of plants varied between one and six peat pots (plants) per plot. Seedlings were clipped back in early June to prepare them for transplanting.

COLORADO POTATO BEETLE EVALUATIONS, 1983-1984

With some introductions duplicated between two test locations, a total of 781 plant introductions were evaluated. They represented 102 species, 34 natural hybrids and 56 crosses made by the Wisconsin Research Foundation. There were 460 plant introductions evaluated at Crookston, Minnesota in 1983 and 496 plant introductions evaluated at Grand Forks, North Dakota in 1984.

In mid-June, seedlings were transplanted into the field. Plants were spaced 0.3 meters apart within rows 1 meter apart. A water soluble fertilizer solution was provided at transplanting. About 5,000 adult Colorado potato beetles were collected from nearby fields and released in the

plots at Grand Forks at transplanting to augment the natural Colorado potato beetle population. There were five replications each year.

Plots were evaluated three times in 1983, on July 7, July 13, and August 5; and twice in 1984, on July 10 and August 4. In 1983, individual plants were scored on this 0-3 scale:

- 0 = no beetle larvae (July 7) or no injury (July 13, August 5)
- 1 = few beetle larvae (July 7) or less than 10% defoliation (July 13, August 5)
- 2 = many larvae (July 7) or more than 10% defoliation (July 13, August 5)
- 3 = 100% defoliation (all dates)

In 1984, individual plants were scored on this 0-3 scale:

- 0 = no injury
- 1 = injury slight, less than 10% defoliation
- 2 = injury moderate to heavy (10-90% defoliation)
- 3 = injury severe (over 90%) or plant dead

With each Colorado potato beetle evaluation, replicate means were calculated for each plant introduction. Corresponding mean evaluation score (average of replicate means) were then calculated. Scoring scales in the two years were virtually identical. Therefore an average across all evaluations was calculated for each plant introduction.

POTATO LEAFHOPPER AND POTATO FLEA BEETLE EVALUATIONS, 1985-1986

Experiments conducted in Rosemount, Minnesota, included 728 plant introductions in 1985 and 713 plant introductions in 1986. With some duplications across the two years, a total of 1,227 introductions were evaluated. They represented 104 species, 42 natural hybrids, and

59 intraspecific crosses made by the Wisconsin Research Foundation.

Seedlings were transplanted into the field in mid-June. Plants were spaced 0.3 meters apart within rows one meter apart. A water soluble fertilizer solution was provided at transplanting. Irrigation was used as necessary to supplement natural rainfall. There were three replications each year. Each replication was planted in a strip, 12 m X 209 m, separated from other replications by equally sized strips of seedling alfalfa. The alfalfa, used to encourage potato leafhopper colonization, was cut two or three times each season.

Plots were sampled using a vacuum machine with a 25 cm diameter hose. A net placed in front of the hose captured the insects dislodged during vacuuming of each plant. Samples were placed in plastic bags and frozen until they could be counted. After each evaluation in 1985, plants were rated for size on a five-point scale where 1 = small and 5 = large. In 1986 the size of a representative plant in each plot was estimated by visualizing it as a cylinder, and measuring the height and diameter of that cylinder.

Potato leafhopper and potato flea beetle populations were evaluated four times in 1985 (August 1–3, August 13–15, August 26–30 and September 11–13) and three times in 1986 (August 5–6, August 19–20 and September 2–4).

Each evaluation, mean number of potato leafhopper nymphs or flea beetle adults in each plot was divided by the number of plants in the plot to obtain the per plant mean. A mean was then calculated for each plant introduction across plot replications. Accession means were summed over evaluations within each season.

The sum leafhopper nymphs or flea beetles per plant were divided by plant size estimates to obtain leafhopper or flea beetle counts adjusted

for size of plant. Regressions of insect count on plant size were used to choose appropriate size adjustment. The appropriate adjustment was judged to be that which made the count most independent of plant size. In 1985, season totals were divided by the plant size evaluation for that plot. In 1986, potato leafhopper season totals were divided by [plant height (cm) X plant width (cm)]. Potato flea beetle season totals were adjusted by an estimate of plant volume made by calculating plant height X (0.5 X plant width)² X π , converted to m³.

CLUSTER ANALYSIS

K-means cluster analysis (Dixon et al. 1983) was used to identify groupings of introductions, based on mean Colorado potato beetle defoliation ratings, size-adjusted potato leafhopper season totals or size adjusted potato flea beetle season totals. The basic unit of observation for cluster analysis was an individual plant introduction. Prior to cluster analysis, size adjusted season totals were transformed to the $\log_{10}(\text{count}+0.01)$ scale. Colorado potato beetle data were not transformed.

Only 754 of the plant introductions were included in the cluster analysis of Colorado potato beetle data; and 1,204 plant introductions were included in the cluster analysis of potato leafhopper and potato flea beetle data. The following *Solanum* species were excluded from the cluster analysis because they did not grow well (i.e., plant height X plant width equalled less than 210 cm²): *S. brachistotrichum*, *S. chiquidenum*, *S. clarum*, *S. colombianum*, *S. fernandezianum*, *S. longiconicum*, *S. morelliforme*, *S. oxycarpum*, *S. paucissectum*, *S. sandemanii*, *S. tuquerrense*, *S. violaceimarmoratum*, and *S. violaceimarmoratum*-*S. yungasensa* hybrids.

RESULTS AND DISCUSSION

COLORADO POTATO BEETLE SCORES

Colorado potato beetle pressure was extremely high in both 1983 and 1984. Mean defoliation rating in those years for plant introductions common to both years was:

0.7 on July 7, 1983;

1.5 on July 13, 1983;

1.7 on August 5, 1983;

1.6 on July 10, 1984; and

1.7 on August 4, 1984.

Cluster analysis was used to divide the plant introductions into six clusters (Table 1). Clusters were arranged in order of increasing mean

defoliation ratings, and numbered sequentially. The cluster number was used as a score to indicate relative level of resistance, with 1 = most resistant, 6 = most susceptible. There were 80 plant introductions in the cluster with the lowest mean defoliation rating (Table 2). These plant introductions were from 11 species and two natural hybrids: *S. alandiae*, *S. berthaultii*, *S. berthaultii*-*S. tarijense* hyb.,

S. capsicibaccatum, *S. chacoense*, *S. circaeifolium*, *S. jamesii*, *S. pinnatisectum*, *S. polyadenium*, *S. sanctae-rosae*, *S. tarijense*, *S. trifidum*, and *S. vernei*-*S. tarijense* hybrids. Species with more than five resistant plant introductions (plant introductions with a score of 1) were: *S. chacoense* (15), *S. jamesii* (6), *S. pinnatisectum* (12), and *S. polyadenium* (8).

Table 1. K-means clustering of Colorado potato beetle screening data: Crookston, Minnesota, 1983; Grand Forks, North Dakota, 1984.

| Score | Cluster Statistics ¹ | | | | Number of Plant Introductions |
|-------|---------------------------------|------|---------|-----|-------------------------------|
| | Minimum | Mean | Maximum | | |
| 1 | 0.05 | 0.37 | 0.63 | 61 | |
| 2 | 0.64 | 0.89 | 1.13 | 78 | |
| 3 | 1.15 | 1.37 | 1.56 | 110 | |
| 4 | 1.56 | 1.75 | 1.92 | 130 | |
| 5 | 1.93 | 2.11 | 2.29 | 171 | |
| 6 | 2.30 | 2.48 | 3.00 | 204 | |

¹ BMDP KM procedure. Colorado potato beetle defoliation rating, 0-3 scale

Table 2. Resistance of exotic potato germplasm to Colorado potato beetle: Crookston, Minnesota, 1983; Grand Forks, North Dakota, 1984.

| Colorado Potato Beetle Score = 1 ¹ | | | | | |
|---|---|---|---|---|---|
| <i>S. alandiae</i> PI 498205 | <i>S. chacoense</i> PI 175415 PI 175419 PI 209411 PI 209412 PI 217451 PI 230862 x PI 230864 | <i>S. circaeifolium</i> PI 473461 | <i>S. pinnatisectum</i> PI 184764 x PI 186553 PI 186553 x PI 184764 PI 186554 PI 186554 x PI 184774 PI 230489 PI 253214 x PI 275233 | <i>S. polyadenium</i> PI 161728 PI 175444 PI 230463 PI 230480 PI 230561 PI 275237 PI 275239 PI 320342 | PI 473227 PI 473241 |
| <i>S. berthaultii</i> PI 473331 | PI 209411 PI 209412 PI 217451 PI 230862 x PI 230864 | <i>S. jamesii</i> PI 275170 x PI 275168 PI 275171 x PI 275168 PI 275173 x PI 275168 | PI 186553 PI 184764 PI 186554 PI 186554 x PI 184774 PI 230489 PI 253214 x PI 275233 | PI 175444 PI 230463 PI 230480 PI 230561 PI 275237 PI 275239 PI 320342 | <i>S. trifidum</i> PI 255539 PI 255542 PI 283104 |
| <i>S. berthaultii</i> - <i>S. tarijense</i> hyb. PI 265577 PI 473334 PI 473336 PI 473338 | PI 230862 x PI 230864 PI 275138 PI 275139 PI 320282 PI 320285 PI 320288 PI 458311 PI 472816 PI 472823 PI 473405 | PI 275168 PI 275171 x PI 275168 PI 275173 x PI 275168 PI 275262 PI 275265 PI 279278 x PI 275266 | PI 186553 PI 184774 PI 230489 PI 253214 x PI 275233 PI 275231 PI 275232 PI 275233 PI 275234 PI 275235 PI 275236 | PI 275237 PI 275239 PI 320342 | <i>S. vernei</i> - <i>S. tarijense</i> hyb. PI 473233 |
| <i>S. capsicibaccatum</i> PI 205560 PI 205560 x PI 210036 | PI 458311 PI 472816 PI 472823 PI 473405 | <i>S. jamesii</i> ? PI 458423 | PI 275231 PI 275232 PI 275233 PI 275234 PI 275235 PI 275236 | <i>S. sanctae-rosae</i> PI 498392 <i>S. tarijense</i> PI 217458 PI 310981 PI 458364 | |

Table 2. (continued)

| | | | | | |
|--|---|---|--|---|---|
| Colorado Potato Beetle Score = 2 | | | | | |
| <i>S. acroglossum</i> PI 365313 | PI 133123 x PI 133659 PI 133127 x PI 133709 | PI 230585 x PI 133709 PI 265576 PI 275141 | <i>S. immitte</i> PI 365330 PI 458401 | <i>S. megistacrobium</i> PI 265879 PI 310977 | <i>S. polyadenium</i> mixture PI 310963 |
| <i>S. berthaultii</i> PI 218215 PI 265858 PI 310925 | PI 133618 x PI 133663 PI 133656 x PI 133659 | PI 275142 x HJE 295.1 PI 320283 PI 320286 | <i>S. infundibuliforme</i> PI 265867 | <i>S. n.sp.</i> ² PI 473209 | <i>S. stoloniferum</i> PI 320343 PI 338621 |
| <i>S. berthaultii-S. tarjense</i> hyb. PI 283070 PI 310927 PI 473332 | PI 175401 PI 175443 x PI 189220 PI 175443 x PI 189220 | PI 320287 PI 320293 PI 414153 PI 472819 PI 472828 PI 472832 | <i>S. jalcae</i> PI 320258 | <i>S. ochranthum</i> PI 473498 | <i>S. tarjense</i> PI 195206 x PI 275154 PI 217457 PI 230466 PI 472814 ³ |
| <i>S. blanco-galdosii</i> ? PI 442701 PI 442702 | PI 189217 x PI 133708 PI 189221 PI 195183 x PI 133663 | <i>S. chomatophilum</i> PI 243340 PI 266387 PI 310943 PI 365324 | <i>S. lignicaule</i> PI 275273 | <i>S. okadae</i> PI 320327 PI 458367 | PI 473217 PI 473226 PI 473235 PI 473236 PI 473237 |
| <i>S. chacoense</i> PI 133073 x PI 133654 PI 133085 x PI 133127 | PI 197760 PI 201846 x PI 230581 PI 230582 | <i>S. x doddsii</i> PI 442690 | <i>S. lycopersi-coides</i> PI 255549 PI 365378 | <i>S. oplocense</i> PI 473368 | <i>S. polyadenium</i> PI 347767 |
| Colorado Potato Beetle Score = 3 | | | | | |
| <i>S. acaule</i> PI 186176 PI 473400 PI 473511 | <i>S. berthaultii-S. tarjense</i> hyb. PI 473333 | <i>S. canasense</i> PI 310955 PI 442696 | PI 320284 PI 320290 | <i>S. gourlayi</i> PI 310931 | <i>S. kurtzianum-S. chacoense</i> hyb. PI 472937 |
| <i>S. acroscopicum</i> PI 365314 PI 365315 | <i>S. boliviense</i> PI 283071 x PI 310975 | <i>S. canasense-S. raphanifolium</i> hyb. PI 310938 | <i>S. chancayense</i> PI 338615 PI 442699 | <i>S. gourlayi-S. incamayoense</i> ? hyb. PI 473090 | <i>S. lignicaule</i> PI 473351 |
| <i>S. albicans</i> PI 266381 | <i>S. brachistotrichum</i> PI 251720 x PI 249927 | <i>S. canasense?</i> PI 265875 | <i>S. chomatophilum</i> PI 243341 PI 310990 PI 310991 PI 365325 PI 473460 | <i>S. immitte</i> PI 365330 x PI 365331 | <i>S. marinasense</i> PI 283079 x PI 283078 PI 310945 PI 310946 PI 365332 PI 498254 |
| <i>S. andreaeanum</i> PI 230458 x PI 247360 PI 320345 | PI 283095 <i>S. brevidens</i> PI 218228 | <i>S. cardiophyllum</i> PI 275216 PI 283063 | <i>S. commercosonii</i> PI 320267 PI 458317 PI 458318 PI 472833 | <i>S. infundibuliforme</i> PI 458326 PI 472885 PI 472902 | <i>S. microdonatum</i> PI 458356 PI 473168 |
| <i>S. berthaultii</i> PI 265857 PI 283069 PI 310926 PI 473330 | <i>S. bukasovii</i> PI 365318 <i>S. bulbocastanum</i> PI 255516 PI 255518 PI 275186 PI 275189 PI 275194 PI 275197 PI 310960 x PI 255518 PI 347757 PI 365379 | <i>S. chacoense</i> PI 133124 x PI 133722 PI 133619 x PI 133664 PI 133710 x PI 133713 PI 133713 x PI 133718 PI 175402 x PI 197758 PI 189220 PI 275136 PI 275140 x PI 275137 | <i>S. demissum</i> PI 161154 PI 161179 PI 175423 | <i>S. lopetalum</i> PI 275181 <i>S. jamesii</i> PI 195190 x PI 275168 PI 283145 x PI 275168 PI 458426 PI 458428 | <i>S. mochiquense</i> PI 283114 PI 338616 <i>S. okadae</i> PI 458368 |
| <i>S. berthaultii-S. tarjense</i> x <i>S. berthaultii</i> PI 320257 x PI 265857 | PI 275197 PI 310960 x PI 255518 PI 347757 PI 365379 | PI 175402 x PI 197758 PI 189220 PI 275136 PI 275140 x PI 275137 | <i>S. etuberosum</i> PI 245924 PI 245939 | <i>S. kurtzianum</i> PI 472930 PI 472934 PI 472936 | <i>S. oplocense</i> PI 458390 PI 473191 PI 473198 |

Table 2. (continued)

| | | | | | |
|--|--|---|--|---|--|
| Colorado Potato Beetle Score = 3 (cont.) | | | | | |
| <i>S. papita</i> PI 262895 | <i>S. polytrichon</i> PI 498276 | <i>S. spegazzinii</i> PI 458399 | <i>S. x sucrense</i> PI 473386 PI 473506 | <i>S. tarjense</i> PI 208881 PI 275154 PI 458394 PI 473220 PI 473222 | <i>S. trifidum</i> PI 255536 PI 255537 PI 498303 |
| <i>S. pescoense</i> ? PI 365339 | <i>S. sanctae-rosae</i> PI 320324 | <i>S. stoloniferum</i> PI 201849 PI 275245 PI 275247 | <i>S. x sucrense-S. tuberosum andigena</i> hyb. PI 473367 | | |
| <i>S. pennellii</i> PI 473422 ³ | <i>S. schenckii</i> PI 275261 | | | | |
| Colorado Potato Beetle Score = 4 | | | | | |
| <i>S. acaule</i> PI 208873 ³ PI 246571 PI 365306 PI 435070 PI 435071 PI 472801 PI 473430 PI 473484 PI 473517 | <i>S. canasense</i> PI 246533 PI 310940 PI 310995 | PI 230589 PI 498231 PI 498233 | <i>S. kurtzianum</i> PI 472931 PI 472933 PI 472935 | <i>S. moscopanum</i> PI 230462 | <i>S. sparsipilum</i> PI 473385 PI 473504 PI 473530 |
| <i>S. alandiae</i> PI 498089 | <i>S. capsicibaccatum</i> PI 473458 | <i>S. x doddsii</i> PI 473350 | <i>S. kurtzianum-S. chacoense</i> hyb. PI 472938 | <i>S. multidissectum-S. canasense</i> hyb. PI 310937 | <i>S. spegazzinii</i> PI 208562 PI 320301 PI 458338 PI 472966 PI 472971 PI 472987 |
| <i>S. albicans</i> PI 310987 PI 365376 | <i>S. cardophyllum</i> PI 186548 PI 275212 PI 275213 PI 275214 PI 347759 | <i>S. fendleri</i> PI 275163 PI 498238 | <i>S. leptophyes</i> PI 265865 PI 473448 | <i>S. neorossii</i> PI 473202 PI 473429 | <i>S. n.sp.</i> ² PI 473210 |
| <i>S. berthaultii-S. tarjense</i> hyb. PI 310971 | <i>S. chacoense</i> PI 189219.8 x PI 189218.7 PI 320289 PI 320292 | <i>S. gourlayi</i> PI 442667 PI 473006 | <i>S. lesteri</i> PI 442694 | <i>S. ochranthum</i> PI 230508 | <i>S. stoloniferum</i> PI 161152 PI 161158 PI 161160 PI 161364 PI 186544 PI 186557 PI 255533 PI 338617 |
| <i>S. brachystotrichum</i> PI 255527 PI 255528 PI 255529 PI 320265 | <i>S. comersonii</i> PI 472834 PI 472837 | <i>S. gourlayi-S. meglistacrobium</i> hyb. PI 473124 | <i>S. marina-sense</i> PI 458380 | <i>S. oplocense</i> PI 473199 | <i>S. x sucrense</i> PI 230465 PI 442692 PI 473364 |
| <i>S. brachycarpum</i> PI 498249 | <i>S. demissum</i> PI 160212 PI 160229 PI 161149 PI 161151 PI 161164 PI 161165 PI 161166 PI 161175 PI 161181 PI 161365 PI 161367 PI 161693 PI 161719 PI 161725 | <i>S. hjertingii</i> PI 251067 | <i>S. meglistacrobium</i> PI 458347 PI 458348 PI 458349 PI 458350 PI 473116 PI 473118 PI 473144 | <i>S. pampasense</i> PI 210046 x PI 275274 | <i>S. papita</i> PI 251740 PI 275228 |
| <i>S. brevidens</i> PI 245764 PI 473401 | <i>S. huancabambense</i> PI 458400 | <i>S. hondelmanii</i> PI 473365 | <i>S. meglistacrobium-S. acaule</i> ? hyb. PI 473524 | <i>S. polytrichon</i> PI 184773 | <i>S. tarjense</i> PI 473216 |
| <i>S. bulbocastanum</i> PI 275193 PI 275200 PI 498223 | <i>S. incamayocense</i> PI 473066 | <i>S. infundibuliforme</i> PI 458320 PI 458325 PI 472908 | <i>S. microdonatum</i> PI 195185 x PI 195200 PI 458355 PI 473167 | <i>S. polytrichon-S. stoloniferum</i> hyb. PI 279308 | <i>S. toralapanum</i> PI 310935 x PI 310936 |
| | <i>S. lopetalum</i> PI 275182 | | <i>S. mochi-quense</i> PI 365334 | <i>S. sanctae-rosae</i> PI 205397 PI 283089 | <i>S. trifidum</i> PI 283064 |
| | | | | <i>S. siliens</i> (= <i>S. rickii</i>) PI 498279 | <i>S. tuberosum</i> subsp. <i>andigena</i> PI 214425 PI 233981 |
| | | | | | <i>S. tuberosum</i> subsp. <i>tuberosum</i> PI 133667 |

Table 2. (continued)

| Colorado Potato Beetle Score = 5 | | | | | |
|--|---|--|---|--|--|
| <i>S. acaule</i> PI 175395 PI 210032 PI 225621 PI 230469 PI 365309 PI 365311 PI 472798 PI 472800 | <i>S. cardiophyllum</i> PI 255520 ³ PI 279272 <i>S. caripense</i> PI 310969 ³ <i>S. chacoense</i> PI 230580 PI 320291 <i>S. curtlobum</i> PI 225650 <i>S. demissum</i> PI 160221 PI 160222 PI 160227 PI 160230 PI 161153 PI 161163 PI 161167 PI 161168 PI 161180 PI 161366 PI 161686 PI 161732 PI 161769 PI 175403 PI 175404 PI 175408 PI 175411 PI 186551 PI 186552 PI 201850 PI 201853 PI 205516 PI 205517 PI 230559 PI 230587 PI 230590 PI 230591 PI 230592 PI 275211 PI 498229 <i>S. fendleri</i> PI 251062 PI 275162 PI 458422 PI 498239 PI 498241 | <i>S. gandarillasii</i> PI 265866 <i>S. gourlayi</i> PI 473007 PI 473030 <i>S. gourlayi-S. incamayoense</i> ? hyb. PI 473088 <i>S. hjertingii</i> PI 251063 <i>S. hougasii</i> PI 161741 x PI 161726 PI 239424 x PI 283107 <i>S. incamayoense</i> PI 473069 PI 473070 PI 473089 <i>S. infundibuliforme</i> PI 414146 PI 458324 PI 472858 PI 472870 PI 472895 <i>S. kurtzianum</i> PI 230584 x PI 133695 <i>S. laxissimum</i> ? PI 283088 <i>S. leptophyes</i> PI 265883 PI 473495 <i>S. marinaense, S. sparsipillum</i> mixture PI 310944 <i>S. medians</i> PI 210045 x PI 230507 PI 265872 PI 320261 | <i>S. megistacrobium</i> PI 275148 PI 275149 PI 458351 PI 473133 <i>S. megistacrobium-S. infundibuliforme</i> hyb. PI 473143 <i>S. microdonatum</i> PI 473171 PI 473173 PI 473174 PI 473179 PI 473180 <i>S. multidissectum</i> PI 210055 PI 473354 <i>S. multidissectum-S. canasense</i> hyb. PI 414155 <i>S. multidissectum</i> ? PI 365353 <i>S. multilinterruptum</i> PI 275272 <i>S. neorossii</i> PI 473201 PI 473428 <i>S. okadae</i> PI 320328 <i>S. oplocense</i> PI 498269 PI 498270 <i>S. pampasense</i> PI 275275 <i>S. phureja</i> PI 320355 PI 320358 <i>S. plurae</i> PI 310997 | <i>S. polytrichon-S. stoloniferum</i> hyb. PI 279280 <i>S. polytrichon-S. stoloniferum</i> ? hyb. PI 275241 <i>S. raphanifolium</i> PI 473502 <i>S. sanctae-rosae</i> PI 218221 PI 230464 PI 275152 PI 473200 <i>S. sanctae-rosae</i> ? PI 320325 <i>S. santolalae</i> PI 195168 <i>S. scabrifolium</i> PI 365363 <i>S. schenckii</i> PI 498250 <i>S. sparsipillum</i> PI 473384 PI 473505 <i>S. spegazzinii</i> PI 205394 PI 205407 PI 310985 PI 472982 PI 472983 PI 472985 PI 472986 <i>S. stenotomum</i> PI 195188 PI 234007 <i>S. stenotomum</i> ? PI 234009 | <i>S. stoloniferum</i> PI 160225 PI 161150 PI 161172 PI 161178 PI 275253 PI 338622 <i>S. x sucrose</i> PI 265885 PI 473388 <i>S. x sucrose x</i> unknown PI 258909 x PI 258911 <i>S. tarjense</i> PI 195206 <i>S. toralapanum</i> PI 310978 PI 320302 PI 320303 PI 458396 PI 472806 <i>S. toralapanum-S. megistacrobium</i> hyb. PI 472804 <i>S. tuberosum</i> subsp. <i>andigena</i> PI 186179 PI 186180 PI 189473 PI 197932 PI 214422 PI 214426 PI 214427 PI 214430 PI 214434 PI 214435 PI 214436 <i>S. vernal</i> PI 320329 PI 473304 <i>S. verrucosum</i> PI 275257 |

Table 2. (continued)

| Colorado Potato Beetle Score = 6 | | | | | |
|--|---|--|--|--|--|
| <i>S. abancayense</i> PI 442700 | <i>S. canasense</i> PI 265863 PI 283074 | PI 338618 PI 338619 | <i>S. marina-sense</i> mixture PI 498256 | <i>S. phureja</i> PI 243463 PI 320348 PI 320349 | <i>S. sparsipilum-S. ?</i> hyb. mixture PI 275153 |
| <i>S. abancayense-S. raphanifolium ?</i> hyb. PI 458403 | PI 283084 PI 442695 PI 458376 PI 473346 PI 473469 | <i>S. fendleri</i> PI 225661 PI 275167 PI 458412 PI 458417 | <i>S. marina-sense?</i> PI 365317 | PI 320350 PI 320351 PI 320352 PI 320353 PI 320354 PI 320357 PI 320359 | <i>S. spagazzinii</i> PI 208876 PI 275143 PI 275144 PI 320299 PI 320300 |
| <i>S. acaule</i> PI 472799 | <i>S. canasense</i> atypical PI 310956 | <i>S. gourlayi</i> PI 265579 PI 283091 PI 320322 PI 458342 | <i>S. mediana</i> PI 210045 PI 283081 PI 310994 PI 320260 PI 458402 PI 473496 | PI 320360 PI 320361 PI 320362 PI 320363 PI 320364 PI 320365 PI 320366 PI 320367 | <i>S. stenotomum</i> PI 195186 x PI 195188 PI 195204 x PI 205526 PI 195214 PI 205526 PI 234008 PI 234010 PI 234015 |
| <i>S. agrimonifolium</i> PI 243349 PI 275177 | <i>S. candolleianum</i> OCH 11814 ³ PI 498226 PI 498227 | <i>S. gourlayi-S. megistacrobium</i> hyb. PI 473136 | <i>S. megistacrobium</i> PI 210034 PI 233125 PI 265578 PI 265873 PI 265874 PI 275147 | PI 320366 PI 320367 | PI 205526 PI 195214 PI 205526 PI 234008 PI 234010 PI 234015 |
| <i>S. ambosinum</i> PI 458405 | <i>S. chacoense</i> PI 133722 x PI 133723 | <i>S. guerrerense</i> PI 161727 PI 161730 | <i>S. microdon-tum</i> PI 320304 PI 458354 | <i>S. polytrichon</i> PI 184770 PI 498274 | PI 234010 PI 234015 |
| <i>S. bolivense</i> PI 265861 PI 310928 PI 310974 PI 310975 | <i>S. curtifolium</i> PI 186181 | <i>S. hjertingii</i> PI 186559 | <i>S. megistacrobium-S. infundibuliforme</i> hyb. PI 473141 | <i>S. polytrichon</i> atypical PI 275240 | <i>S. stoloniferum</i> PI 161171 PI 161281 PI 239411 PI 243459 PI 275246 PI 275250 PI 498287 |
| <i>S. brachistotrichum</i> PI 498216 | <i>S. demissum</i> PI 160208 PI 160220 PI 161155 PI 161169 PI 161176 PI 161715 PI 161729 PI 161731 PI 175405 PI 175409 PI 186556 PI 186561 PI 201851 PI 201854 PI 205514 PI 205518 PI 205519 PI 205625 PI 218047 PI 225652 PI 225711 PI 230487 PI 230488 PI 230558 PI 230578 PI 230579 PI 275206 PI 275207 PI 275208 PI 275209 PI 275210 PI 310961 PI 310962 | <i>S. hondelmanii</i> PI 473366 | <i>S. huancabambense</i> PI 365406 PI 498243 PI 498244 | <i>S. polytrichon-S. stoloniferum</i> hyb. PI 498275 | PI 161171 PI 161281 PI 239411 PI 243459 PI 275246 PI 275250 PI 498287 |
| <i>S. brachycarpum</i> PI 275179 PI 275183 PI 498251 | PI 161176 PI 161715 PI 161729 PI 161731 PI 175405 PI 175409 PI 186556 PI 186561 PI 201851 PI 201854 PI 205514 PI 205518 PI 205519 PI 205625 PI 218047 PI 225652 PI 225711 PI 230487 PI 230488 PI 230558 PI 230578 PI 230579 PI 275206 PI 275207 PI 275208 PI 275209 PI 275210 PI 310961 PI 310962 | <i>S. incamayense</i> PI 473067 PI 473068 | <i>S. microdon-tum</i> PI 320304 PI 458354 | <i>S. raphanifolium ?</i> PI 473371 | <i>S. x sucrose</i> PI 458389 |
| <i>S. brevidens</i> PI 245763 | PI 161176 PI 161715 PI 161729 PI 161731 PI 175405 PI 175409 PI 186556 PI 186561 PI 201851 PI 201854 PI 205514 PI 205518 PI 205519 PI 205625 PI 218047 PI 225652 PI 225711 PI 230487 PI 230488 PI 230558 PI 230578 PI 230579 PI 275206 PI 275207 PI 275208 PI 275209 PI 275210 PI 310961 PI 310962 | <i>S. kurtzianum</i> PI 230584 x PI 133687 PI 472927 | <i>S. multidissectum</i> PI 296123 ³ | <i>S. raphanifolium ?</i> mixture PI 310951 | <i>S. toralapanum</i> PI 310936 PI 473389 |
| <i>S. bukasovii</i> PI 210042 PI 210043 PI 266385 PI 473494 PI 498221 | PI 161176 PI 161715 PI 161729 PI 161731 PI 175405 PI 175409 PI 186556 PI 186561 PI 201851 PI 201854 PI 205514 PI 205518 PI 205519 PI 205625 PI 218047 PI 225652 PI 225711 PI 230487 PI 230488 PI 230558 PI 230578 PI 230579 PI 275206 PI 275207 PI 275208 PI 275209 PI 275210 PI 310961 PI 310962 | <i>S. infundibuliforme</i> PI 458322 PI 472864 PI 472865 | <i>S. multidissectum-S. canasense</i> hyb. PI 473450 | <i>S. sanctae-rosae</i> PI 320323 | <i>S. tuberosum</i> subsp. <i>andigena</i> PI 186178 PI 195162 PI 205393 x PI 205396 PI 209426 PI 209433 PI 214421 x PI 214431 PI 214424 PI 214441 PI 214442 PI 214443 PI 217448 PI 230470 PI 230471 PI 233984 PI 233988 PI 243391 |
| <i>S. bukasovii</i> atypical PI 265876 | PI 161176 PI 161715 PI 161729 PI 161731 PI 175405 PI 175409 PI 186556 PI 186561 PI 201851 PI 201854 PI 205514 PI 205518 PI 205519 PI 205625 PI 218047 PI 225652 PI 225711 PI 230487 PI 230488 PI 230558 PI 230578 PI 230579 PI 275206 PI 275207 PI 275208 PI 275209 PI 275210 PI 310961 PI 310962 | <i>S. kurtzianum-S. chacoense</i> hyb. PI 472924 | <i>S. multidissectum ?</i> PI 442698 | <i>S. santolallae</i> PI 473372 | <i>S. x sucrose</i> PI 458389 |
| <i>S. bukasovii</i> mixture PI 210052 | PI 161176 PI 161715 PI 161729 PI 161731 PI 175405 PI 175409 PI 186556 PI 186561 PI 201851 PI 201854 PI 205514 PI 205518 PI 205519 PI 205625 PI 218047 PI 225652 PI 225711 PI 230487 PI 230488 PI 230558 PI 230578 PI 230579 PI 275206 PI 275207 PI 275208 PI 275209 PI 275210 PI 310961 PI 310962 | <i>S. leptophyes</i> PI 458378 | <i>S. multilinterruptum</i> PI 265886 PI 365336 PI 365337 | <i>S. schenckii</i> PI 498280 | <i>S. tuberosum</i> subsp. <i>andigena</i> PI 186178 PI 195162 PI 205393 x PI 205396 PI 209426 PI 209433 PI 214421 x PI 214431 PI 214424 PI 214441 PI 214442 PI 214443 PI 217448 PI 230470 PI 230471 PI 233984 PI 233988 PI 243391 |
| <i>S. bulbocastanum</i> PI 498225 | PI 161176 PI 161715 PI 161729 PI 161731 PI 175405 PI 175409 PI 186556 PI 186561 PI 201851 PI 201854 PI 205514 PI 205518 PI 205519 PI 205625 PI 218047 PI 225652 PI 225711 PI 230487 PI 230488 PI 230558 PI 230578 PI 230579 PI 275206 PI 275207 PI 275208 PI 275209 PI 275210 PI 310961 PI 310962 | <i>S. ignicaule</i> PI 498253 | <i>S. neorossii</i> PI 473529 | <i>S. sogardinum</i> PI 230510 | <i>S. sparsipilum</i> PI 473503 PI 473531 PI 473532 |

Table 2. (continued)

| Colorado Potato Beetle Score = 6 (cont.) | | | |
|--|-----------|-----------------------|----------------------|
| <i>S. vernal</i> | PI 320333 | <i>S. vernal</i> - | <i>S. verrucosum</i> |
| PI 230468 | PI 458369 | <i>S. spagazzinii</i> | PI 195170 |
| PI 320330 | PI 458370 | hyb. | |
| PI 320332 | | PI 230562 | |

¹ Accessions were divided into resistance classes (Table 1). Accessions with a score of 1 were highly resistant to Colorado potato beetle. A "hyb." indicates a natural hybrid. *S. x sucrense* and *S. x doddsii* are natural hybrids that have been given species designation. An "x" between two species names indicates an artificial cross. A "?" indicates probable species identification.

² Species description has not yet been published in the taxonomic literature.

³ Accession no longer maintained in IR-1 collection at Sturgeon Bay, Wisconsin.

POTATO LEAFHOPPER SCORES

Total potato leafhopper counts ranged from 0 to 11.7 per plant in 1985 and from 0 to 26.9 per plant in 1986. Among the plant introductions were 28 that were common both to these potato leafhopper trials and to a 1966 screening trial previously reported (Radcliffe and Lauer 1968). These were used as standards for comparison of potato leafhopper and potato flea beetle population pressure across years. Mean potato leafhopper nymphs per plant (season total over all evaluations, unadjusted for plant size) for the 28 standard plant introductions was 1.1 in 1985, and 2.5 in 1986. In 1985 and 1986, mean potato leafhopper nymphs per plant was:

- 0.1 for August 1–3, 1985;
- 0.4 for August 13–15, 1985;
- 0.6 for August 26–30, 1985;
- 0.02 for September 11–13, 1985;
- 1.3 for August 3–5, 1986;
- 0.9 for August 19–20, 1986; and
- 0.3 for September 2–4, 1986.

After plant size adjustment, cluster analysis indicated four clusters were appropriate each year (Table 3).

By convention, clusters were numbered in order of field resistance, and for this paper cluster ranks were treated as resistance scores. Thus, a score of 1 indicated that this plant introduction was in the cluster most resistant to potato leafhopper and a score of 4 indicated the plant introduction was in the cluster most susceptible to potato leafhopper. Populations of potato leafhopper were higher in 1986 than in 1985, so results from this year gave the most rigorous

separation of resistant plant introductions. Therefore, when data were available from both years, data from 1986 were used in preference to that of 1985. The numbers of introductions at each potato leafhopper score were (Table 4):

- 116 had a score of 1;
- 336 had a score of 2;
- 424 had a score of 3; and
- 328 had a score of 4.

Unlike resistance to Colorado potato beetle, which is concentrated in a relatively few species, potato leafhopper resistance (score = 1) occurred in 49 species or species hybrids (Table 5). Species with more than five resistant plant introductions (plant introductions with a score of 1) were: *S. berthaultii* (11), *S. brachycarpum* (7), *S. chacoense* (9), *S. demissum* (12), and *S. polyadenium* (6).

POTATO FLEA BEETLE SCORES

The totals for potato flea beetle counts ranged from 0.2 to 49.9 per plant in 1985, and from 0 to 30.2 per plant in 1986. The mean for potato flea beetle adults per plant (season total over all evaluations, unadjusted for plant size) for the 28 standard plant introductions were 5.77 in 1985 and 1.44 in 1986. In 1985 and 1986, mean potato flea beetle adults per plant were:

- 1.4 for August 1–3, 1985;
- 0.8 for August 13–15, 1985;
- 0.8 for August 26–30, 1985;
- 2.7 for September 11–13, 1985;

0.3 for August 3–5, 1986;
 0.5 for August 19–20, 1986; and
 0.6 for September 2–4, 1986.

After plant size adjustment, cluster analysis indicated five clusters were appropriate each year, based on number of potato flea beetle per plant (Table 3).

As with the other insects, clusters were arranged such that cluster 1 contained those plant introductions that were most resistant to potato flea beetle, and cluster 5 contained those most susceptible to potato flea beetle. Populations of flea beetles were higher in 1985 than 1986, so results from this year gave the most rigorous separation of resistant plant introductions. Therefore, when data were available from both years, data from 1985 were used in preference to

1986. Numbers of introductions at each respective potato flea beetle resistance score were (Table 4):

102 had a score of 1;
 197 had a score of 2;
 273 had a score of 3;
 374 had a score of 4; and
 258 had a score of 5.

Potato flea beetle resistance (score = 1) occurred in 33 species or hybrids (Table 5). Species with more than five resistant plant introductions (plants with a score of 1) were: *S. berthaultii* (6), *S. bulbocastanum* (16), *S. megistacrolobum* (5), *S. microdontum* (7), *S. polyadenium* (6), *S. stoloniferum* (6), and *S. toralapanum* (6).

Table 3. K-means clustering of potato germplasm screening data: Rosemount, Minnesota, 1985–86.

| Score | Cluster Statistics ¹ | | | Number of Plant Introductions |
|---|---------------------------------|-------|---------|-------------------------------|
| | Minimum | Mean | Maximum | |
| Potato leafhopper (PLH) 1985 ² | | | | |
| 1 | -2.00 | -1.83 | -1.44 | 62 |
| 2 | -1.40 | -1.02 | -0.74 | 215 |
| 3 | -0.73 | -0.47 | -0.20 | 228 |
| 4 | -0.20 | -0.06 | 0.64 | 204 |
| Potato leafhopper 1986 ³ | | | | |
| 1 | -2.00 | -1.59 | -1.40 | 86 |
| 2 | -1.40 | -1.21 | -1.03 | 191 |
| 3 | -1.02 | -0.84 | -0.66 | 261 |
| 4 | -0.65 | -0.47 | 0.04 | 167 |
| Potato flea beetle (PFB) 1985 ⁴ | | | | |
| 1 | -0.95 | -0.47 | -0.29 | 83 |
| 2 | -0.27 | -0.07 | 0.09 | 134 |
| 3 | 0.09 | 0.25 | 0.40 | 154 |
| 4 | 0.40 | 0.56 | 0.73 | 193 |
| 5 | 0.74 | 0.91 | 1.24 | 145 |
| Potato flea beetle 1986 ⁵ | | | | |
| 1 | -2.00 | -0.21 | 0.71 | 55 |
| 2 | 0.73 | 1.04 | 1.27 | 109 |
| 3 | 1.28 | 1.52 | 1.73 | 167 |
| 4 | 1.75 | 1.97 | 2.21 | 229 |
| 5 | 2.22 | 2.51 | 4.59 | 145 |

¹ BMDP KM procedure.
² \log_{10} [mean (plh per plant / plant size rating) + 0.01]
³ \log_{10} [mean (plh per plant / (height x width)) + 0.01]
⁴ \log_{10} [mean (pfb per plant / plant size rating) + 0.01]
⁵ \log_{10} [mean (pfb per m²) + 0.01]

Table 4. Distribution of potato leafhopper and potato flea beetle scores: Rosemount, Minnesota, 1985–86.

| Number of introductions with potato flea beetle score of: ¹ | Number of plant introductions with potato leafhopper score of: ¹ | | | | |
|--|---|-----|-----|-----|-------|
| | 1 | 2 | 3 | 4 | Total |
| 1 | 17 | 36 | 37 | 12 | 102 |
| 2 | 24 | 73 | 68 | 32 | 197 |
| 3 | 18 | 86 | 103 | 66 | 273 |
| 4 | 35 | 97 | 133 | 109 | 374 |
| 5 | 22 | 44 | 83 | 109 | 258 |
| Total | 116 | 336 | 424 | 328 | 1,204 |

¹ Insect scores determined using cluster analysis (Table 3).

Table 5. Resistance of exotic potato germplasm to potato leafhopper and potato flea beetle: Rosemount, Minnesota, 1985–86.

| | | | | | |
|--|--|--|---|--|--|
| Potato leafhopper score = 1, Potato flea beetle score = 1¹ | | | | | |
| <i>S. andreaenum</i> PI 230458 x PI 247360 | <i>S. berthaultii</i> - <i>S. tarjense</i> x <i>S. berthaultii</i> PI 320257 x PI 265857 | <i>S. berthaultii</i> - <i>S. tarjense</i> hyb. PI 473334 | <i>S. ochranthum</i> PI 473498 | <i>S. polyadenium</i> PI 161728 | <i>S. polyadenium</i> mixture PI 310963 |
| <i>S. berthaultii</i> PI 473330 PI 498102 PI 498107 PI 498109 | PI 320257 x PI 265858 | <i>S. multilinter-</i> <i>ruptum</i> PI 365336 | <i>S. pennellii</i> PI 473464 ² | PI 275237 PI 275238 PI 498273 | <i>S. toralapanum</i> PI 195210 |
| Potato leafhopper score = 1, Potato flea beetle score = 2 | | | | | |
| <i>S. berthaultii</i> PI 218215 PI 265857 PI 265858 PI 473331 PI 498101 PI 498103 PI 498105 | <i>S. berthaultii</i> - <i>S. tarjense</i> hyb. PI 310927 PI 473336 PI 473338 | <i>S. bulbocastanum</i> PI 283096 x PI 275196 | <i>S. kurtzianum</i> PI 472963 | <i>S. papita atypical</i> PI 498027 | <i>S. polytrichon-</i> <i>S. stoloniferum</i> ? hyb. PI 275241 |
| | <i>S. bukasovii</i> ? PI 365351 | <i>S. chacoense</i> PI 472812 | <i>S. lesteri</i> PI 442694 | <i>S. polyadenium</i> PI 320342 | <i>S. tarjense</i> PI 473228 PI 500054 |
| | | <i>S. chancayense</i> PI 338615 | <i>S. neocardenasii</i> PI 498129 | <i>S. polytrichon</i> PI 186545 | <i>S. toralapanum</i> PI 310936 |
| Potato leafhopper score = 1, Potato flea beetle score = 3 | | | | | |
| <i>S. albomozil</i> PI 498206 | <i>S. cardophyllum</i> PI 283063 | <i>S. circaefolium</i> PI 498116 | <i>S. gourlayi</i> PI 473031 PI 473059 | <i>S. megistacrobium</i> PI 473359 | <i>S. pinnatisectum</i> PI 275232 |
| <i>S. brachycarpum</i> PI 498020 | <i>S. chacoense</i> PI 230862 x PI 230864 | <i>S. demissum</i> PI 161166 PI 175423 | <i>S. lycopersicoides</i> PI 255549 | <i>S. mochiquense</i> PI 365334 | <i>S. polyadenium</i> PI 347767 |
| <i>S. canasense</i> PI 283084 | PI 320286 | <i>S. fendleri</i> PI 498240 | <i>S. medians</i> PI 310994 | | |

Table 5. (continued)

| | | | | | |
|--|---|--|---|---|---|
| Potato leafhopper score = 1, Potato flea beetle score = 4 | | | | | |
| <i>S. abancayense-S. raphanifolium</i> ? hyb. PI 458404 | <i>S. chacoense</i> PI 133123 x PI 133656 PI 133127 x PI 133709 PI 175401-1.5 x PI 175443-1.1 | <i>S. demissum</i> PI 161176 PI 161769 PI 186562 PI 201851 PI 205517 PI 230578 PI 230590 PI 365383 PI 365385 | <i>S. gourlayi</i> PI 442668 <i>S. jamesii</i> PI 275171 x PI 275168 <i>S. lycopersicoides</i> PI 365378 | <i>S. meglistacrobium</i> PI 473118 <i>S. pinnatisectum</i> PI 275230 <i>S. polytrichon</i> PI 184770 | <i>S. tuberosum</i> subsp. <i>andigena</i> PI 225630 PI 281005 <i>S. verrucosum</i> PI 275256 PI 275259 |
| <i>S. acaule</i> PI 473431 | PI 197758 | PI 365385 | <i>S. medians</i> PI 320260 | <i>S. tarjense</i> PI 458365 PI 472814 ² | |
| <i>S. albicans</i> PI 266381 | PI 175402 x PI 197758 | <i>S. dollochocremastrum</i> ? PI 498236 | | | |
| <i>S. brachycarpum</i> PI 230459 PI 255514 | PI 473406 PI 498320 <i>S. comersonii</i> PI 472851 | | | | |
| Potato leafhopper score = 1, Potato flea beetle score = 5 | | | | | |
| <i>S. acroscopium</i> PI 365314 | <i>S. brachycarpum</i> PI 239402 PI 498022 PI 498023 PI 498249 | <i>S. canasense</i> PI 473355 <i>S. demissum</i> PI 161180 <i>S. etuberosum</i> PI 498412 <i>S. kurtzianum</i> PI 472928 | <i>S. kurtzianum-S. chacoense</i> hyb. PI 472924 <i>S. laxissimum</i> ? PI 283088 | <i>S. multidissectum</i> PI 473352 <i>S. okadae</i> PI 458368 PI 498403 <i>S. polytrichon-S. stoloniferum</i> hyb. PI 283106 | <i>S. santolalae</i> PI 195168 <i>S. tuberosum</i> subsp. <i>andigena</i> PI 281093 <i>S. verrucosum</i> PI 251758 |
| <i>S. agrimonifolium</i> PI 243352 PI 275177 | <i>S. brevidens</i> PI 218228 PI 245764 | | | | |
| Potato leafhopper score = 2, Potato flea beetle score = 1 | | | | | |
| <i>S. berthaultii</i> HHA 6542 PI 498108 | <i>S. brachistotrichum</i> PI 320265 PI 498216 <i>S. bulbocastanum</i> PI 243512 PI 255516 PI 275188 PI 275189 PI 275192 PI 275194 | PI 275198 PI 310960 x PI 255518 <i>S. cardophyllum</i> PI 275216 <i>S. chacoense</i> PI 320291 PI 472819 <i>S. dollochocremastrum</i> ? PI 498235 | <i>S. immitis</i> PI 365330 <i>S. lignicaule</i> PI 275273 PI 473351 <i>S. meglistacrobium</i> PI 265879 <i>S. microdonatum</i> PI 473176 | <i>S. multilinterruptum</i> ? PI 498266 <i>S. pampasense</i> PI 275274 PI 275275 <i>S. polyadenium</i> PI 275239 PI 347769 | <i>S. polytrichon</i> PI 184773 PI 186547 <i>S. tarjense</i> PI 473217 PI 473241 <i>S. toralapanum</i> PI 472805 <i>S. vernalis-S. tarjense</i> hyb. PI 473240 |
| <i>S. berthaultii-S. tarjense</i> hyb. PI 498094 | | | | | |
| <i>S. blanco-galdosii</i> ? PI 442701 PI 442702 PI 498214 | | | | | |
| Potato leafhopper score = 2, Potato flea beetle score = 2 | | | | | |
| <i>S. acroglossum</i> PI 365313 | <i>S. berthaultii-S. tarjense</i> hyb. PI 265577 PI 473333 PI 498095 PI 498099 | <i>S. brachistotrichum</i> PI 251720 x PI 249927 PI 255528 <i>S. bukasovii</i> ? PI 473449 | <i>S. bulbocastanum</i> PI 255518 PI 275196 PI 275200 PI 498224 PI 498225 <i>S. canasense</i> PI 230511 PI 458375 | <i>S. cardophyllum</i> PI 186548 PI 275213 PI 279272 <i>S. chacoense</i> PI 133619 x PI 133664 PI 458314 PI 498318 | <i>S. demissum</i> PI 230592 <i>S. gourlayi</i> PI 458343 PI 473036 <i>S. gourlayi-S. infundibuliforme</i> hyb. PI 472920 |
| <i>S. andreaeanum</i> PI 498148 | | | | | |
| <i>S. berthaultii</i> PI 498106 | | | | | |

Table 5. (continued)

| | | | | | |
|--|--|---|---|--|--|
| Potato leafhopper score = 2, Potato flea beetle score = 2 (cont.) | | | | | |
| <i>S. hougasil</i> PI 161726 | <i>S. medians</i> PI 265872 | <i>S. mochi-</i> <i>quense</i> PI 338616 | <i>S. polyaden-</i> <i>ium</i> PI 230463 | <i>S. tarijense</i> PI 217458 | <i>S. toralapanum</i> PI 458396 |
| PI 161741 x PI 161726 | <i>S. meglistacro-</i> <i>lobum</i> PI 473358 | <i>S. multinter-</i> <i>ruptum</i> ? PI 498267 | PI 230480 PI 347768 | PI 310981 PI 414150 PI 442689 | <i>S. trifidum</i> PI 283104 |
| <i>S. immitis</i> PI 365330 x PI 365331 | PI 473360 | PI 498267 | <i>S. polytrichon</i> PI 498276 | PI 458364 PI 458366 PI 473222 | <i>S. vernal</i> PI 473311 |
| <i>S. incamay-</i> <i>oense</i> PI 473067 | <i>S. meglistacro-</i> <i>lobum-S. infun-</i> <i>dibulliforme</i> hyb. PI 473143 | <i>S. pampa-</i> <i>sense</i> PI 442697 | <i>S. schenckii</i> PI 498040 | PI 473224 PI 473225 PI 473229 | <i>S. vernal-</i> <i>S. tarijense</i> hyb. PI 473231 |
| <i>S. lopetalum</i> PI 275182 | <i>S. microdon-</i> <i>tum</i> PI 320306 | <i>S. pinnatisec-</i> <i>tum</i> PI 186553 x PI 184764 | <i>S. spegazzinii</i> ? PI 472970 | PI 473235 PI 473236 PI 473237 | PI 473232 |
| <i>S. leptophyes</i> PI 265883 | PI 320306 | PI 275233 PI 275235 | <i>S. stoloniferum</i> PI 275249 PI 338617 | PI 473242 PI 473243 | <i>S. verrucosum</i> PI 310966 |
| Potato leafhopper score = 2, Potato flea beetle score = 3 | | | | | |
| <i>S. abancay-</i> <i>ense</i> PI 442700 | PI 175401-1.5 x PI 175446.1 | <i>S. gourlayi</i> PI 458339 | <i>S. laxissimum</i> PI 498252 | <i>S. polytrichon</i> PI 255547 | PI 473234 PI 473238 PI 473245 |
| <i>S. acaule</i> PI 365309 | PI 195183 x PI 133663 | PI 458340 PI 473020 PI 473025 | <i>S. medians</i> PI 283081 PI 473496 | <i>S. polytrichon</i> atypical PI 275240 | <i>S. toralapanum</i> PI 473114 |
| <i>S. berthaultii</i> PI 498100 | PI 230580 PI 320281 PI 320285 | <i>S. guerrer-</i> <i>oense</i> PI 161730 | <i>S. meglistacro-</i> <i>lobum</i> PI 473144 | <i>S. raphanifolium</i> PI 473502 | <i>S. tuberosum</i> subsp. <i>and-</i> <i>igena</i> PI 473252 |
| <i>S. berthaultii-</i> <i>S. tarijense</i> hyb. PI 310971 | PI 458310 PI 472821 PI 472827 | <i>S. (herrerse)</i> PI 230503 ² | PI 473356 | <i>S. schenckii</i> PI 498041 PI 498250 | PI 473275 |
| PI 473332 | PI 472828 | <i>S. hjertingii</i> PI 186560 | <i>S. multinter-</i> <i>ruptum</i> PI 275272 | <i>S. sogaran-</i> <i>dinum</i> PI 230510 | <i>S. vernal</i> PI 500069 |
| PI 498097 | <i>S. chancay-</i> <i>ense</i> PI 442699 | <i>S. hougasil</i> PI 161174 | <i>S. multinter-</i> <i>ruptum</i> ? PI 498265 | <i>S. spegazzinii</i> PI 472967 PI 472984 PI 472988 | <i>S. vernal-</i> <i>S. tarijense</i> hyb. PI 473233 |
| PI 498098 | <i>S. commerc-</i> <i>sonii</i> PI 472850 | <i>S. incamay-</i> <i>oense</i> PI 473089 | <i>S. pinnatisec-</i> <i>tum</i> PI 186554 x PI 184764 | <i>S. tarijense</i> PI 208881 PI 217457 | <i>S. verrucosum</i> PI 195170 PI 195172 |
| <i>S. brachistotri-</i> <i>chum</i> PI 255527 | PI 498416 | <i>S. infundibul-</i> <i>forme</i> PI 275146 | PI 186554 x PI 184774 | PI 275154 PI 414148 PI 473216 | PI 498062 |
| PI 255529 | <i>S. demissum</i> PI 160208 | <i>S. kurtzianum</i> PI 175434 PI 472921 | PI 275231 PI 275234 PI 347766 | PI 473216 PI 473223 PI 473226 | |
| <i>S. brachycar-</i> <i>pum</i> PI 243344 | PI 175403 | | <i>S. polyaden-</i> <i>ium</i> PI 175444 | PI 473230 | |
| PI 498021 | PI 205518 PI 230559 PI 275209 | | | | |
| <i>S. canasense</i> PI 310955 | PI 310962 | | | | |
| <i>S. chacoense</i> PI 133618 x PI 133663 | | | | | |
| Potato leafhopper score = 2, Potato flea beetle score = 4 | | | | | |
| <i>S. abancayen-</i> <i>se-S. raphani-</i> <i>folium</i> ? hyb. PI 458403 | <i>S. acaule</i> PI 365305 PI 473484 | <i>S.acro-</i> <i>scopicum</i> PI 365315 | <i>S. ambos-</i> <i>inum</i> ? PI 498212 | <i>S. brachycar-</i> <i>pum</i> atypical PI 498025 | <i>S. candol-</i> <i>leanum</i> PI 498226 PI 498313 |
| | | <i>S. albicans</i> PI 310987 | <i>S. brachycar-</i> <i>pum</i> PI 498251 | <i>S. bukasovii</i> PI 266385 | |

Table 5. (continued)

| | | | | | |
|---|--|---|--|--|---|
| Potato leafhopper score = 2, Potato flea beetle score = 4 (cont.) | | | | | |
| <i>S. cardiophyllum</i> PI 184762 PI 251725 x PI 251759 PI 279274 x PI 279303 PI 283062 | PI 472831 PI 473405 <i>S. chomatophilum</i> PI 243340 PI 266387 PI 310943 | PI 186561 PI 201850 PI 218047 PI 230487 PI 230488 PI 230587 PI 275208 PI 347761 | <i>S. huancabambense</i> PI 498413 <i>S. infundibuliforme</i> PI 458322 PI 472862 PI 472908 <i>S. jamesii</i> PI 275170 x PI 275168 PI 275263 PI 283145 x PI 275168 PI 458428 <i>S. kurtzianum</i> PI 230584 x PI 133695 PI 458328 PI 472960 <i>S. kurtzianum-S. chacoense</i> hyb. PI 458329 | <i>S. medians</i> PI 210045 x PI 230507 <i>S. megistacrobium</i> PI 473111 PI 473112 PI 473152 PI 473159 <i>S. moscopenum</i> PI 230462 <i>S. okadae</i> PI 458367 <i>S. phureja</i> PI 320363 <i>S. raphanifolium</i> PI 210049 <i>S. sogarandinum-S. ?</i> hyb. PI 365360 | <i>S. sparsipilum</i> PI 275276 <i>S. spegazzinii</i> PI 208562 PI 472987 <i>S. tarjense</i> PI 195206 x PI 275154 PI 230466 <i>S. trifidum</i> PI 255537 <i>S. tuberosum</i> subsp. <i>andigena</i> PI 161716 PI 186177 PI 243404 PI 243406 unknown PI 473477 <i>S. verrucosum</i> PI 160228 PI 275255 |
| <i>S. chacoense</i> PI 133085 x PI 133127 PI 133123 x PI 133659 PI 175419 PI 189215 x PI 133664 PI 230585 x PI 133709 PI 275141 PI 320282 PI 320283 PI 320294 PI 414153 PI 458313 PI 458316 | <i>S. comersonii</i> PI 320266 <i>S. demissum</i> PI 160212 PI 160230 PI 161151 PI 161155 PI 161168 PI 161169 PI 161179 PI 161365 PI 161366 PI 161715 PI 161732 PI 175411 PI 186551 | <i>S. dollchocremastrum ?</i> PI 498234 <i>S. fendleri</i> PI 283100 PI 458417 <i>S. gandarillasii</i> PI 283076 <i>S. gourlayi</i> PI 442673 PI 473010 PI 473058 <i>S. guerrerocense</i> PI 161727 | | | |
| Potato leafhopper score = 2, Potato flea beetle score = 5 | | | | | |
| <i>S. acaule</i> PI 195161 <i>S. agrimonifolium</i> PI 243349 <i>S. berthaultii</i> PI 310926 <i>S. brachycarpum</i> PI 275179 PI 275183 PI 498024 <i>S. bukasovii</i> PI 473494 PI 498219 | <i>S. bukasovii</i> mixture PI 210052 <i>S. bukasovii ?</i> PI 473452 <i>S. canasense</i> PI 310940 <i>S. chacoense</i> PI 175415 PI 175443 x PI 189220 PI 189220 PI 189221 PI 320289 | <i>S. comersonii</i> PI 472843 <i>S. demissum</i> PI 161181 PI 161725 PI 175408 PI 230589 PI 275206 PI 338618 <i>S. etuberosum</i> PI 245924 PI 245939 | <i>S. jamesii</i> PI 458425 PI 458426 <i>S. kurtzianum</i> PI 472923 PI 472927 PI 472955 <i>S. kurtzianum-S. chacoense</i> hyb. PI 498360 <i>S. kurtzianum ?</i> PI 472922 | <i>S. medians</i> PI 320261 <i>S. multidissectum-S. canasense</i> hyb. PI 473450 <i>S. multilinterruptum</i> PI 365338 <i>S. okadae</i> PI 320327 <i>S. sparsipilum</i> PI 246536 | <i>S. spegazzinii</i> PI 320299 <i>S. stenotomum</i> PI 234012 <i>S. x sucrose</i> PI 230465 <i>S. tuberosum</i> subsp. <i>andigena</i> PI 214427 PI 243390 PI 473259 <i>S. vernal</i> PI 498406 ² |
| Potato leafhopper score = 3, Potato flea beetle score = 1 | | | | | |
| <i>S. brachistotrichum</i> PI 255530 <i>S. bulbocastanum</i> PI 243506 PI 243510 | PI 275184 PI 275186 PI 275187 PI 275197 PI 275199 PI 347757 | <i>S. capsicibacatum</i> PI 205560 x PI 210036 <i>S. chacoense</i> PI 275142 x HJE 295.1 PI 472823 | <i>S. chomatophilum</i> PI 365325 <i>S. infundibuliforme</i> PI 458321 | <i>S. lignicaule</i> PI 310993 <i>S. marinasense</i> PI 310945 PI 458380 | <i>S. megistacrobium</i> PI 210034 PI 275147 PI 473109 PI 473131 |

Table 5. (continued)

| | | | | | |
|---|---|--|---|--|--|
| Potato leafhopper score = 3, Potato flea beetle score = 1 (cont.) | | | | | |
| <i>S. megistacrolobum-S. infundibuliforme</i> hyb. PI 473141 | <i>S. microdon-tum</i> PI 208866 PI 473170 PI 473178 PI 500038 | <i>S. mochli-quense</i> PI 283114 <i>S. plurae</i> PI 310997 | <i>S. polytrichon</i> PI 365393 <i>S. spgazzinii</i> PI 472982 | <i>S. stoloniferum</i> PI 195167 PI 275252 <i>S. toralapanum</i> PI 472806 PI 472807 | PI 472808 PI 473389 <i>S. toralapanum-S. megistacrolobum</i> hyb. PI 472804 |
| Potato leafhopper score = 3, Potato flea beetle score = 2 | | | | | |
| <i>S. alandiae</i> PI 498087 PI 498089 PI 498205 | <i>S. canasense</i> ? PI 265875 <i>S. capsicibac-catum</i> PI 205560 <i>S. cardiophyl-lum</i> PI 275215 PI 347759 <i>S. chacoense</i> PI 472824 PI 472832 <i>S. circasifol-lum</i> PI 473461 <i>S. dolichocre-mastrum</i> ? PI 498237 <i>S. fendleri</i> PI 275157 | <i>S. gourlayi</i> PI 265579 PI 435074 PI 458344 <i>S. gourlayi-S. incamay-oense</i> ? hyb. PI 473090 <i>S. gourlayi-S. megistacrolobum</i> hyb. PI 473136 <i>S. immite</i> PI 458401 <i>S. incamay-oense</i> PI 473070 <i>S. infundibul-forme</i> PI 283077 PI 472902 PI 472905 PI 473521 | <i>S. lopetalum</i> PI 275181 <i>S. marina-sense</i> PI 283079 x PI 283078 PI 498255 <i>S. marina-sense</i> mixture PI 498256 <i>S. megistacrolobum</i> PI 265874 PI 458346 PI 473361 <i>S. microdon-tum</i> PI 458354 PI 458356 PI 473173 PI 500032 PI 500064 | <i>S. multilinter-ruptum</i> PI 265886 <i>S. okadae</i> PI 498063 <i>S. pampa-sense</i> PI 458381 <i>S. papita</i> PI 283102 <i>S. phureja</i> PI 225665 <i>S. pinnatisec-tum</i> PI 186554 PI 275236 <i>S. polyaden-lum</i> PI 230561 | <i>S. sanctae-rosae</i> PI 230464 <i>S. santolalae</i> PI 473372 <i>S. stoloniferum</i> PI 160224 PI 186563 PI 201855 PI 230490 PI 283109 PI 310964 PI 338621 PI 365394 <i>S. tarjense</i> PI 414149 <i>S. trifidum</i> PI 255536 PI 255540 PI 498303 <i>S. verrucosum</i> PI 275260 |
| Potato leafhopper score = 3, Potato flea beetle score = 3 | | | | | |
| <i>S. acaule</i> PI 472646 | <i>S. brevicaule</i> PI 310930 | <i>S. cardiophyl-lum</i> PI 255520 ² PI 275214 PI 279303 x PI 184766 | <i>S. demissum</i> PI 160227 PI 186552 <i>S. x doddsii</i> PI 473350 <i>S. fendleri</i> PI 275163 <i>S. gourlayi</i> PI 435073 PI 442671 PI 442672 PI 458341 PI 472911 PI 473002 PI 473005 PI 473006 PI 473008 PI 473015 | PI 473016 PI 473029 PI 473030 PI 473047 PI 473049 PI 473050 PI 473053 PI 473072 PI 473099 <i>S. hjertingii</i> PI 186559 PI 283103 <i>S. hougasii</i> PI 239423 x PI 161726 <i>S. incamay-oense</i> PI 473068 | <i>S. infundibul-forme</i> PI 431500 PI 442675 PI 442677 PI 472858 PI 472877 <i>S. kurtzianum</i> PI 472936 <i>S. kurtzianum</i> x <i>S. bukasovii</i> PI 230584 x (PI 210042 x PI 210043 x PI 210044) <i>S. medians</i> PI 210045 |
| <i>S. andreaum</i> PI 320345 | <i>S. bukasovii</i> PI 210051 | <i>S. chacoense</i> PI 133710 x PI 133713 PI 189217 x PI 133708 PI 209411 PI 320288 PI 414144 PI 473404 <i>S. commer-sonii</i> PI 458317 | <i>S. berthaultii</i> PI 283069 <i>S. berthaultii-S. tarjense</i> hyb. PI 473339 <i>S. brachistotri-chum</i> PI 497993 | <i>S. bulbocae-tanum</i> PI 243345 PI 243504 PI 243508 PI 243513 PI 365379 <i>S. canasense</i> PI 246533 <i>S. capsicibac-catum</i> PI 473458 PI 498120 | <i>S. acule</i> PI 472646 <i>S. andreaum</i> PI 320345 <i>S. avilesii</i> PI 498092 <i>S. berthaultii</i> PI 283069 <i>S. berthaultii-S. tarjense</i> hyb. PI 473339 <i>S. brachistotri-chum</i> PI 497993 |

Table 5. (continued)

| | | | | | |
|---|-------------------------|---------------------------------|----------------------------|-----------------------------------|------------------------|
| Potato leafhopper score = 3, Potato flea beetle score = 3 (cont.) | | | | | |
| <i>S. megistacrolobum</i> | <i>S. papita</i> | <i>S. polytrichon</i> | <i>S. stoloniferum</i> | <i>S. trifidum</i> | <i>S. vernei</i> |
| PI 458349 | PI 251740 | PI 255526 | PI 275248 | PI 255538 | PI 320333 |
| PI 473133 | PI 498032 | | PI 338620 | PI 255539 | PI 458369 |
| PI 473147 | <i>S. phureja</i> | <i>S. raphanifolium</i> | PI 498287 | PI 255542 | PI 458371 |
| | PI 225693 | PI 310999 | | | PI 473304 |
| <i>S. microdonatum</i> | <i>S. pinnatisectum</i> | <i>S. scabrifolium</i> | <i>S. x sucrense</i> | <i>S. tuberosum</i> | <i>S. verrucosum</i> |
| PI 473177 | PI 230489 | PI 365363 | PI 473381 | subsp. <i>andigena</i> | PI 195171 |
| | PI 253214 x | <i>S. schenckii</i> | PI 498295 | PI 280941 | PI 275257 |
| <i>S. neocrossii</i> | PI 275233 | PI 275261 | PI 498301 | PI 281037 | |
| PI 473529 | | PI 498042 | <i>S. tarijense</i> | PI 473251 | |
| | | | PI 473218 | PI 473258 | |
| <i>S. oplocense</i> | <i>S. plurae</i> | <i>S. spegazzinii</i> | PI 473220 | | |
| PI 458361 | PI 473501 | PI 275144 | PI 473227 | | |
| | | | PI 473244 | | |
| Potato leafhopper score = 3, Potato flea beetle score = 4 | | | | | |
| <i>S. acule</i> | PI 175443 x | PI 473019 | <i>S. megistacrolobum</i> | <i>S. phureja</i> | <i>S. stoloniferum</i> |
| PI 210030 | PI 189220 | PI 473024 | PI 233125 | PI 225675 | PI 275250 |
| PI 217449 | PI 230582 | PI 473043 | PI 458348 | PI 243461 | |
| PI 217450 | PI 265576 | PI 473084 | PI 498263 | PI 275110 | <i>S. tarijense</i> |
| PI 230529 | PI 320287 | PI 498329 | | PI 310489 x | PI 195206 |
| PI 472637 | PI 458315 | | <i>S. microdonatum</i> | PI 310492 | <i>S. toralapanum</i> |
| PI 472647 | PI 472816 | <i>S. gourlayi</i> | PI 320304 | PI 320357 | PI 310978 |
| PI 473517 | PI 472826 | <i>S. infundibuliforme</i> hyb. | | PI 320368 | PI 458397 |
| | PI 472829 | PI 473038 | <i>S. multidissectum</i> | PI 320373 | PI 498144 |
| <i>S. ambosinum</i> | <i>S. chacoense</i> | <i>S. infundibuliforme</i> | PI 473353 | <i>S. phureja</i> x | <i>S. tuberosum</i> |
| PI 458405 | <i>S. tarijense</i> | PI 414146 | PI 473354 | <i>S. demissum</i> | subsp. <i>andigena</i> |
| | mixture | PI 435075 | | PI 230586 x | PI 186180 |
| <i>S. ambosinum</i> ? | PI 195184 | PI 442674 | <i>S. multidissectum</i> ? | PI 230587 | PI 225632 |
| PI 365362 | <i>S. curtislobum</i> | PI 472870 | PI 498210 | <i>S. phureja</i> ? | PI 230470 |
| PI 498208 | PI 186181 | PI 472871 | | PI 498213 | PI 232054 |
| PI 498209 | <i>S. demissum</i> | PI 472883 | <i>S. okadae</i> | <i>S. raphanifolium</i> ? mixture | PI 233993 |
| | PI 161164 | PI 472892 | PI 320328 | PI 310951 | PI 243380 |
| <i>S. berthaultii</i> | PI 161686 | PI 472895 | PI 500061 | | PI 243407 |
| <i>S. tarijense</i> | PI 161693 | PI 472906 | <i>S. oplocense</i> | <i>S. schenckii</i> | PI 246979 |
| hyb. | PI 161719 | PI 472914 | PI 442682 | PI 498280 | PI 280921 |
| PI 283070 | PI 161729 | | PI 442683 | | PI 280926 |
| | PI 205625 | <i>S. jamesii</i> | PI 442684 | <i>S. sparsipilum</i> | PI 473264 |
| <i>S. bukasovii</i> | PI 225652 | PI 275169 | PI 473186 | PI 458388 | PI 473270 |
| PI 275271 | PI 347760 | PI 275266 | PI 473190 | | PI 473277 |
| | | PI 458424 | PI 473368 | <i>S. sparsipilum</i> | PI 473288 |
| <i>S. bukasovii</i> | <i>S. fendleri</i> | | PI 473500 | <i>S. ?</i> hyb. mixture | PI 473292 |
| atypical | PI 251062 | <i>S. jamesii</i> ? | PI 498070 | PI 275153 | PI 498077 |
| PI 265876 | PI 275164 | PI 458423 | PI 498270 | | |
| | PI 275167 | <i>S. kurtzianum</i> | | <i>S. spegazzinii</i> | unknown |
| <i>S. canasense</i> | PI 458342 | PI 498422 | <i>S. papita</i> | PI 208876 | PI 498173 |
| PI 210035 | PI 472992 | | PI 249929 | PI 320301 | <i>S. vernei</i> |
| PI 473347 | PI 472995 | <i>S. leptophyes</i> | PI 283108 | PI 458398 | PI 458370 |
| PI 473349 | PI 473003 | PI 265865 | PI 283143 | PI 500053 | |
| PI 473447 | PI 473018 | | | <i>S. stenotomum</i> | <i>S. verrucosum</i> |
| | | | | PI 195188 | PI 161173 |
| <i>S. chacoense</i> | | | | | PI 338624 |
| PI 133656 x | | | | | PI 498010 |
| PI 133659 | | | | | |
| PI 175401 | | | | | |

Table 5. (continued)

| | | | | | |
|--|---|---|---|--|--|
| Potato leafhopper score = 3, Potato flea beetle score = 5 | | | | | |
| <i>S. acaule</i> PI 195160 | <i>S. cardiophyllum</i> PI 184767 x PI 184771 | <i>S. infundibuliforme</i> PI 265867 PI 458325 PI 472859 | <i>S. marina-sense</i> ? PI 365317 | PI 225705 PI 283118 PI 320348 PI 320371 | <i>S. stenotomum</i> ? PI 234009 |
| PI 205508 PI 225621 PI 275132 PI 473329 PI 473518 | <i>S. chomatophilum</i> PI 243341 | PI 472864 PI 472866 PI 472867 PI 472909 | <i>S. meglstacrobium</i> PI 473116 PI 473150 | <i>S. raphanifolium</i> PI 265878 | <i>S. tuberosum</i> subsp. <i>andigena</i> PI 161350 PI 214426 PI 230500 PI 233984 PI 243369 PI 243384 PI 280990 PI 281059 PI 281088 PI 365403 PI 473267 PI 473269 PI 473295 PI 498294 |
| <i>S. scroglossum</i> PI 498204 | <i>S. demissum</i> PI 160222 PI 161149 | <i>S. jamesii</i> PI 195190 x PI 275168 | <i>S. multidissectum</i> PI 473491 PI 498304 | <i>S. sparsipilum</i> PI 473373 PI 473505 | PI 161350 PI 214426 PI 230500 PI 233984 PI 243369 PI 243384 PI 280990 PI 281059 PI 281088 PI 365403 PI 473267 PI 473269 PI 473295 PI 498294 |
| <i>S. berthaultii</i> <i>S. tarijense</i> hyb. PI 473335 | PI 338619 PI 347762 | PI 275173 x PI 275168 PI 275262 | <i>S. multidissectum</i> ? PI 442698 | <i>S. spegazzinii</i> PI 205394 PI 275143 PI 320300 PI 458399 | PI 243384 PI 280990 PI 281059 PI 281088 PI 365403 PI 473267 PI 473269 PI 473295 PI 498294 |
| <i>S. brachistotrichum</i> PI 283095 | <i>S. gandavillasi</i> PI 265866 | <i>S. kurtzianum</i> PI 320271 PI 320297 | <i>S. paucijugum</i> ? PI 473421 | <i>S. stenotomum</i> PI 195214 PI 205527 PI 234007 PI 234011 PI 365344 PI 458393 | PI 473269 PI 473295 PI 498294 |
| <i>S. bukasovii</i> PI 210043 PI 365321 | <i>S. huancabambense</i> PI 498243 PI 498244 | PI 472945 PI 472965 | <i>S. phureja</i> PI 225670 PI 225677 PI 225687 PI 225703 | PI 234007 PI 234011 PI 365344 PI 458393 | <i>S. verrucosum</i> PI 275258 PI 320344 |
| <i>S. candolleianum</i> PI 498227 | | <i>S. leptophyes</i> PI 473448 PI 473451 | | | |
| Potato leafhopper score = 4, Potato flea beetle score = 1 | | | | | |
| <i>S. marina-sense, S. sparsipilum</i> mixture PI 310944 | <i>S. microdonatum</i> PI 218222 PI 473169 | <i>S. sanctae-rosae</i> PI 283089 PI 473200 PI 498392 | <i>S. spegazzinii</i> PI 472974 | <i>S. stoloniferum</i> PI 161160 PI 230557 PI 255532 PI 275246 | <i>S. tarijense</i> PI 414152 |
| Potato leafhopper score = 4, Potato flea beetle score = 2 | | | | | |
| <i>S. alandiae</i> PI 498085 PI 498086 PI 498090 | <i>S. chacoense</i> PI 320290 PI 498316 | <i>S. gourlayi-S. incamay- oense</i> ? hyb. PI 473088 | <i>S. meglstacrobium</i> PI 265578 | <i>S. papita</i> PI 262895 | PI 161170 PI 161178 PI 195166 PI 230477 PI 243458 PI 255525 PI 310980 PI 347772 |
| <i>S. blanco-galdosii</i> PI 365368 | <i>S. fendleri</i> PI 225661 | <i>S. incamay- oense</i> PI 473066 | <i>S. neorossii</i> PI 473201 PI 473202 | <i>S. sanctae-rosae</i> PI 205397 PI 218221 PI 275152 | |
| <i>S. canasense</i> PI 283074 | <i>S. fendleri</i> ? PI 255543 | <i>S. infundibuliforme</i> PI 472865 PI 472894 | <i>S. n. sp.</i> ³ PI 473209 | <i>S. stoloniferum</i> PI 160226 PI 160372 | |
| | <i>S. gourlayi</i> PI 473009 | | | | |
| Potato leafhopper score = 4, Potato flea beetle score = 3 | | | | | |
| <i>S. alandiae</i> PI 498088 | <i>S. brevicaule</i> PI 498111 | <i>S. canasense</i> PI 265863 PI 458377 PI 473346 | <i>S. canasense-S. raphanifolium</i> hyb. PI 310938 | <i>S. chacoense</i> PI 209412 PI 275138 PI 275139 PI 472830 PI 473403 PI 500042 | <i>S. commersonii</i> PI 458319 PI 472834 <i>S. demissum</i> PI 161163 |
| <i>S. boliviense</i> PI 265861 PI 498215 | <i>S. bukasovii</i> PI 473492 | | | | |

Table 5. (continued)

| | | | | | |
|--|--|---|--|---|--|
| Potato leafhopper score = 4, Potato flea beetle score = 3 (cont.) | | | | | |
| <i>S. fendleri</i> K-5332 | <i>S. hjertingii</i> PI 251063 PI 251065 | <i>S. marina-</i> <i>sense</i> PI 310946 PI 498254 | <i>S. papita</i> PI 275227 | PI 195164 PI 195195 PI 205510 PI 205522 PI 239411 PI 498002 | <i>S. tuberosum</i> subsp. <i>andl-</i> <i>gena</i> PI 233996 PI 258893 x PI 258895 PI 473301 PI 498076 |
| <i>S. gourlayi</i> PI 210038 PI 320322 PI 442670 PI 472993 PI 473000 PI 473014 PI 473032 PI 473063 PI 473081 PI 473087 | <i>S. infundibul-</i> <i>forme</i> PI 472896 | <i>S. neorossii</i> PI 473428 | <i>S. raphani-</i> <i>folium</i> PI 210048 PI 473528 | <i>S. x sucrense</i> PI 473392 PI 498300 PI 498306 | <i>S. vernal</i> PI 230468 PI 473310 |
| | <i>S. jamesii</i> PI 279278 x PI 275266 | <i>S. okadae</i> PI 498130 | <i>S. sanctae-</i> <i>rosae</i> PI 498391 | <i>S. trifidum</i> PI 255541 | <i>S. vernal-</i> <i>S. spegazzinii</i> hyb. PI 230562 |
| | <i>S. leptophyes</i> PI 458378 PI 473445 | <i>S. oplocense</i> PI 458390 PI 473189 PI 473195 | <i>S. spegazzinii</i> PI 458334 | | |
| | | | <i>S. stoloniferum</i> PI 160225 PI 161150 | | |
| Potato leafhopper score = 4, Potato flea beetle score = 4 | | | | | |
| <i>S. acaule</i> PI 208874 PI 210029 PI 472643 PI 473511 PI 473519 | <i>S. commer-</i> <i>sonii</i> PI 320267 | PI 472869 PI 472878 PI 472885 PI 473522 PI 498347 | <i>S. papita</i> PI 251741 PI 283105 PI 498035 | <i>S. spegazzinii</i> PI 458336 PI 458338 | PI 281013 PI 281215 PI 281256 PI 296086 x PI 296087 |
| <i>S. bolivense</i> PI 310928 PI 310975 | <i>S. curtlobum</i> PI 225649 PI 234005 x PI 258900 PI 258900 ² | <i>S. jamesii</i> PI 275265 | <i>S. phureja</i> PI 225678 PI 225681 PI 225686 PI 225710 PI 243466 PI 283120 PI 283121 PI 283123 PI 283125 PI 320352 PI 320366 | <i>S. stenotomum</i> PI 283141 | PI 365346 PI 473250 PI 473255 PI 473261 PI 473262 PI 473268 PI 473284 PI 473286 PI 473290 PI 473293 PI 473297 PI 473298 PI 473300 PI 498292 |
| <i>S. brevicaule</i> PI 498110 | <i>S. demissum</i> PI 205514 | <i>S. leptophyes</i> PI 473383 | <i>S. ilmbanlense</i> PI 473468 | <i>S. x sucrense</i> PI 265885 | PI 473268 PI 473284 PI 473286 PI 473290 PI 473293 PI 473297 PI 473298 PI 473300 PI 498292 |
| <i>S. canasense</i> PI 442696 | <i>S. fendleri</i> PI 458412 | <i>S. megistacro-</i> <i>lobum</i> PI 473155 | <i>S. multidisec-</i> <i>tum</i> PI 320340 | <i>S. tuberosum</i> subsp. <i>andl-</i> <i>gena</i> PI 195162 PI 230472 PI 243362 PI 243387 PI 243422 PI 243430 PI 243436 PI 246521 PI 255503 PI 258922 x PI 258923 PI 265868 PI 280869 PI 280909 PI 280971 PI 280981 | PI 473286 PI 473286 PI 473290 PI 473293 PI 473297 PI 473298 PI 473300 PI 498292 |
| <i>S. cana-</i> <i>sense</i> ? PI 365361 | <i>S. gourlayi</i> PI 473056 PI 473061 PI 473064 PI 473071 | <i>S. multidisec-</i> <i>tum</i> PI 320340 | <i>S. raphani-</i> <i>folium</i> PI 265862 PI 473466 PI 473467 | | PI 473290 PI 473293 PI 473297 PI 473298 PI 473300 PI 498292 |
| <i>S. chacoense</i> PI 458311 PI 472820 PI 473402 | <i>S. hjertingii</i> PI 251067 | <i>S. neorossii</i> PI 473429 | <i>S. sparsipilum</i> PI 311000 PI 473530 | | PI 473298 PI 473300 PI 498292 |
| <i>S. chomato-</i> <i>philum</i> PI 310990 | <i>S. incamay-</i> <i>oense</i> PI 473069 | <i>S. oplocense</i> PI 435079 PI 473183 PI 473187 PI 473193 PI 473198 PI 498068 | <i>S. sparsipilum-</i> <i>S. raphani-</i> <i>folium</i> hyb. PI 283086 | | PI 161401 PI 245813 x PI 245314 |
| <i>S. circae-</i> <i>folium</i> PI 498119 | <i>S. infundibul-</i> <i>forme</i> PI 442676 PI 458326 PI 472868 | | | | PI 161401 PI 245813 x PI 245314 |
| Potato leafhopper score = 4, Potato flea beetle score = 5 | | | | | |
| <i>S. acaule</i> PI 175395 PI 246504 | <i>S. bolivense</i> PI 265860 | <i>S. bukasovii</i> PI 210042 PI 230506 PI 365352 | <i>S. bukasovii</i> ? PI 473453 | <i>S. circae-</i> <i>folium</i> PI 498117 | <i>S. gourlayi</i> PI 442667 PI 442669 PI 473013 PI 473041 |
| | <i>S. brevicaule</i> PI 498112 | | <i>S. chacoense</i> PI 320293 | | |

Table 5. (continued)

| Potato leafhopper score = 4, Potato flea beetle score = 5 (cont.) | | | | | |
|---|---------------------------------|-----------------------|------------------------------|-------------|-------------|
| <i>S. hondelman- nil</i> | <i>S. megistacro- lobum</i> | <i>S. sparsipilum</i> | <i>S. x sucrense</i> | PI 243453 | PI 324461 x |
| PI 473365 | PI 473129 | PI 210039 | PI 442691 | PI 245928 | PI 324456 |
| PI 473380 | | PI 310972 | PI 458389 | PI 246497 | PI 338623 |
| PI 498067 | <i>S. oplocense</i> | PI 310984 | PI 498302 | PI 246499 | PI 365402 |
| | PI 473194 | PI 458386 | | PI 255494 | PI 473249 |
| <i>S. huancabam- bense</i> | PI 498389 | PI 473375 | <i>S. tuberosum</i> | PI 255496 | PI 473260 |
| PI 458400 | <i>S. phureja</i> | PI 473376 | subsp. <i>andl- gena</i> | PI 255497 | PI 473263 |
| | PI 195191 | PI 473384 | PI 160215 | PI 258870 | PI 473278 |
| <i>S. infundibul- forme</i> | PI 225674 | PI 473503 | PI 161131 | PI 258879 | PI 473281 |
| PI 472863 | PI 225676 | <i>S. spegazzinii</i> | PI 205622 | PI 258898 | PI 473287 |
| PI 472880 | PI 225682 | PI 472990 | PI 209419 | PI 258936 | PI 473294 |
| PI 472893 | PI 225701 | <i>S. stenotomum</i> | PI 214430 | PI 280883 | PI 473296 |
| | PI 243463 | PI 205526 | PI 225627 | PI 280907 | PI 473299 |
| <i>S. jamesii</i> | PI 243469 | PI 230512 | PI 230474 | PI 280952 | PI 498291 |
| PI 275264 | PI 283116 | PI 230513 | PI 230499 | PI 281012 | PI 498307 |
| PI 458427 | PI 283119 | PI 234008 | PI 232046 | PI 281126 | PI 500056 |
| | PI 320355 | PI 234010 | PI 232839 | PI 281189 | unknown |
| <i>S. leptophyes</i> | PI 320359 | PI 234013 | PI 243360 | PI 281227 | PI 498171 |
| PI 473387 ¹ | PI 320369 | PI 234015 | PI 243398 | PI 292086 | |
| PI 473495 | PI 320370 | | PI 243401 | PI 308867 x | |
| | | | | PI 308883 | |

¹ Accessions were divided into resistance classes (Tables 3 and 4). Accessions with an insect score of 1 were highly resistant to that insect. A "hyb." indicates a natural hybrid. *S. x sucrense* and *S. x doddsii* are natural hybrids that have been given species designation. An "x" between two species names indicates an artificial cross. A "?" indicates probable species identification.

² Accession no longer maintained in IR-1 collection at Sturgeon Bay, Wisconsin.

³ Species description has not yet been published in the taxonomic literature.

PLANT INTRODUCTIONS NOT INCLUDED IN CLUSTER ANALYSIS

A number of plant introductions grew poorly in these trials and were not included in the cluster analyses for resistance to the three insect pests. Results from these plants are reported here.

COLORADO POTATO BEETLE

Colorado potato beetle defoliation ratings (0–3 scale) for the plant introductions not included in the cluster analysis were: *S. brachistotrichum*, PI 498217, 1.4; *S. chiquidenum*, PI 365323, 1.0 and PI 473459, 1.4; *S. clarum*, PI 243355 X PI 275205 (WRF 1568), 1.4, and PI 283099, 1.2; *S. colombianum*, PI 310983, 1.9, and PI 320346, 2.2; *S. fernandezianum*, PI 320270, 1.0, and PI 473463, 0.7; *S. morelliforme*, PI 243357, 2.4, PI 275220, 1.7, and PI 275221, 2.3; *S. oxycarpum*, PI 230479, 1.7, and PI 498272, 2.4; *S. paucissectum*, PI 365340, 0.6 and PI 473489, 1.2; *S. sandemanii*, PI 265880, 1.4,

and PI 442703, 1.4; *S. tuquerrense*, PI 246971, 2.3 and PI 338614, 2.3; *S. violaceimarmoratum*, PI 258856, 1.5, PI 473395, 1.6, and PI 473396, 2.2; and *S. violaceimarmoratum-S. yungasensa* hybrid, PI 498314, 0.4.

POTATO LEAFHOPPER

Sum potato leafhopper nymphs per plant (unadjusted for plant size) for plant introductions evaluated in 1985 and not included in the cluster analysis were: *S. brachistotrichum*, PI 498217, 0.2; *S. clarum*, PI 283099, 0.5; *S. colombianum*, PI 247322, 0.0, and PI 310983, 0.0; *S. colombianum*?, PI 473407, 0.5; *S. fernandezianum*, PI 320270, 0.1; *S. longiconicum*, PI 186568, 0.0; *S. oxycarpum*, PI 230479, 0.0, and PI 498272, 0.0; *S. paucissectum*?, PI 473489, 0.4; *S. sandemanii*, PI 442703, 0.9; *S. violaceimarmoratum*, PI 473395, 0.5, PI 473396, 0.0, and PI 498296, 0.5; *S. violaceimarmoratum-yungasensa* hybrid, PI 473397, 0.5.

Sum potato leafhopper nymphs per plant (unadjusted for plant size) for plant introductions evaluated in 1986 and not included in the cluster analysis were: *S. chiquidenum*, PI 365323, 5.8; *S. colombianum*, PI 473462, 2.5; *S. fernandezianum*, PI 473463, 1.0; *S. oxycarpum*, PI 275224, 2.9; *S. paucissectum*, PI 365340, 2.0; *S. sandemanii*, PI 265880, 3.1; *S. tuquerrense*, PI 338614, 2.4; and *S. violaceimarmoratum*-*S. yungasensa* hybrid, PI 498314, 0.2.

POTATO FLEA BEETLE

Sum potato flea beetle adults per plant (unadjusted for plant size) for plant introductions evaluated in 1985 and not included in the cluster analysis were: *S. brachistotrichum*, PI 498217, 0.5; *S. clarum*, PI 283099, 8.2; *S. colombianum*, PI 247322, 2.2, and PI 310983, 11.0; *S. colombianum* ?, PI 473407, 12.5;

S. fernandezianum, PI 320270, 9.8, and PI 473463, 17.4; *S. longiconicum*, PI 186568, 7.3; *S. oxycarpum*, PI 230479, 2.2, PI 275224, 5.3, and PI 498272, 2.0; *S. paucissectum*, PI 365340, 0.2; *S. paucissectum* ?, PI 473489, 1.8; *S. sandemanii*, PI 265880, 0.6, and PI 442703, 1.6; *S. violaceimarmoratum*, PI 473395, 3.8, PI 473396, 7.4, and PI 498296, 4.8; and *S. violaceimarmoratum*-*S. yungasensa* hybrid, PI 473397, 2.5.

Sum potato flea beetle adults per plant (unadjusted for plant size) for plant introductions evaluated in 1986 and not included in the cluster analysis were: *S. chiquidenum*, PI 365323, 0.4; *S. colombianum*, PI 473462, 0.0; *S. fernandezianum*, PI 473436, 0.0; *S. oxycarpum*, PI 275224, 1.9; *S. paucissectum*, PI 365340, 0.7; *S. sandemanii*, PI 265880, 0.1; *S. tuquerrense*, PI 338614, 0.9; and *S. violaceimarmoratum*-*S. yungasensa* hybrid, PI 498314, 0.0.

SUMMARY

The Irish potato, *Solanum tuberosum* subsp. *tuberosum*, is the world's fourth most important crop, but it is only one of a large group of tuber-bearing *Solanum* species. Seven species are cultivated, the rest are referred to as "wild", or "exotic." The sheer number and diversity of the wild potatoes can be bewildering. The tuber-bearing *Solanum* species and their immediate relatives consist of 235 described species (Hawkes 1990).

Exotic potatoes provide many sources of insect resistance that may have potential value to plant breeders. To date they have been under utilized. Historically, breeders have looked to exotic species, especially the more primitive ones, only for desirable traits not otherwise available in the cultivated potatoes.

In the past, primary crosses between certain wild and cultivated species have been difficult if not impossible to achieve. Often this has been due to ploidy differences, as in diploid x tetraploid crosses, or to endosperm balance number differences (Ehlenfeldt and Hanneman 1984). Manipulation of these factors often permits breeders to overcome hybridization difficulties, so that today most wild species can be crossed with the cultivated potatoes.

We found Colorado potato beetle resistant plant

introductions to be of frequent occurrence among the more primitive diploid species, e.g., *S. capsicibaccatum*, *S. circaeifolium*, *S. jamesii*, *S. pinnatisectum*, *S. polyadenium*, and *S. trifidum*. Colorado potato beetle resistant plant introductions also occurred in the more advanced diploids *S. alandiae*, *S. berthaultii*, *S. chacoense*, *S. sanctae-rosae*, and *S. tarijense*.

No tetraploid or hexaploid plant introductions had a Colorado potato beetle score of 1. *Solanum tuberosum* is a tetraploid with an endosperm balance number of 4.

Among the most primitive diploids, potato leafhopper resistant plant introductions were identified in: *S. brevidens*, *S. bulbocastanum*, *S. cardiophyllum*, *S. circaeifolium*, *S. commersonii*, *S. etuberosum*, *S. jamesii*, *S. lesteri*, *S. lycopersicoides*, *S. mochiquense*, *S. ochranthum*, *S. polyadenium*, and *S. pinnatisectum*. In the more advanced diploids, potato leafhopper resistant plant introductions were identified in: *S. acroscopicum*, *S. albornozii*, *S. andreanum*, *S. berthaultii*, *S. bukasovii*, *S. canasense*, *S. chacoense*, *S. chancayense*, *S. kurtzianum*, *S. laxissimum*, *S. medians*, *S. megistacrolobum*, *S. multidissectum*, *S. multiinterruptum*, *S. neocardenasii*, *S. okadae*, *S. santolallae*, *S. tarijense*, *S. toralapanum*, and *S. verrucosum*.

In the tetraploids with an endosperm balance number of 2, potato leafhopper resistant plant introductions were identified in: *S. acaule*, *S. agrimonifolium*, *S. fendleri*, *S. papita*, and *S. polytrichon*. Two potato leafhopper resistant introductions in the species *S. gourlayi* are tetraploid with an endosperm balance number of 4. One is a diploid, with an endosperm balance number of 2. Potato leafhopper resistant plant introductions in *Solanum tuberosum* subsp. *andigena* are tetraploid, with an endosperm balance number of 4.

In hexaploids with an endosperm balance number of 4, potato leafhopper resistant plant introductions were identified in *S. albicans*, *S. brachycarpum*, and *S. demissum*.

S. pennellii, a leafhopper resistant diploid, is best placed as a *Lycopersicon* rather than a *Solanum* species, although it possesses features of both (Miller and Tanksley 1990). Chromosome number and endosperm balance number of *S. dolichocremastrum*, which contains potato leafhopper resistant germplasm, was not available at this writing. It is in the series *Tuberosa*.

Among the most primitive diploids, potato flea beetle resistant plant introductions were identified in: *S. brachistotrichum*, *S. bulbocastanum*, *S. capsicibaccatum*, *S. cardiophyllum*, *S. lignicaule*, *S. mochiquense*,

S. ochranthum, and *S. polyadenium*. In the more advanced diploids, potato flea beetle resistant plant introductions were identified in *S. andreanum*, *S. berthaultii*, *S. blanco-galdosii*, *S. chacoense*, *S. chomatophilum*, *S. immite*, *S. infundibuliforme*, *S. marinasense*, *S. megistacrolobum*, *S. microdontum*, *S. multiinterruptum*, *S. pampasense*, *S. piurae*, *S. sanctae-rosae*, *S. spagazzinii*, *S. tarijense*, and *S. toralapanum*.

In the tetraploids, with an endosperm balance number of 2, potato flea beetle resistant plant introductions were identified in *S. polytrichon* and *S. stoloniferum*.

There were no flea beetle resistant plant introductions in the hexaploids.

Potato flea beetle resistant plant introductions were identified in *S. pennellii* and *S. dolichocremastrum*.

There are many and diverse sources of insect resistance among exotic potato germplasm. Most of these sources are in species that have never been used in potato breeding programs intended to transfer useful characteristics to advanced breeding lines. Advances in breeding now permit many if not all of these sources to be considered. This study's data should be useful in assisting breeders in choosing germplasm for future plant breeding programs.

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