Literature Cited

Barthlott, W. 1979. Cacti. Stanley Thornes, Cheltenham, England.

Barthlott, W. 1983. Biogeography and evolution in neo- and paleotropical Rhipsalinae (Cactaceae). Sonderbd. Naturwiss. Ver. Hamburg 7:241-248.

Barthlott, W. 1987. New names in Rhipsalidinae (Cactaceae). Bradleya 5:97-100.

Boyle, T. H., D.J. Jacques, and D.P. Stimart. 1988. Influence of photoperiod and growth regulators on flowering of *Rhipsalidopsis gaertneri.* J. Amer. Soc. Hort. Sci. 113:75–78.

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agricultural research. 2nd ed. Wiley, New York.

Graf, A.B. 1974. Exotic plant manual. 4th ed. Roehrs, East Rutherford, N.J.

Liberty Hyde Bailey Hortorium. 1976. Hortus third: A concise dictionary of plants cultivated in the United States and Canada. 3rd ed. Macmillan, New York.

List, R.J. 1951. Smithsonian meteorological tables. 6th ed. Smithsonian Institution, Washington, D.C.

McMillan, A.J.S. 1981. *Rhipsalidopsis* Br. and R. Epiphytes 6:3-7.

Peters, J. and W. Rünger. 1971. Blütenbildung von *Rhipsalidopsis gaertneri.* Gartenbauwissenschaft 36:155-174.

Rünger, W. 1960. Uber den Einflu β der Temperature und der Tageslange auf die Blütenbildung von *Rhipsalidopsis × graeseri.* Zeitschrift Bot. 48:381-397.

Wilkins, H.F. and W. Rünger. 1985. *Rhipsalidopsis.* In: A.H. Halevy (cd.). Handbook of flowering. vol. IV. CRC Press, Boca Raton, Fla.

HortScience 25(2):219-222. 1990.

Developmental Specific Isozyme Expression in Peach

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Additional index words. electrophoresis, fruit breeding, allozyme

Abstract. **To determine the earliest developmental stage at which isozyme screening could be accomplished, 10 isozyme systems were examined in peach [*Prunus persica* (L.) Batsch] for differential expression during development. Differences in isozyme expression based on stage of development were detected in nine systems. The earliest stage for complete screening of most isozymes examined is in l-month-old seedlings. The significance of these results relative to genetic mapping is discussed.**

Isozyme polymorphism that could be useful for genetic mapping has been reported in peach and in species within the same subgenus. Polymorphism for malate dehydrogenase (Arulsekar et al., 1986a; Arulsekar et al., 1986b; Durham et al., 1987; Mowrey et al., 1990a); isocitrate dehydrogenase (Mowrey et al., 1990a), peroxidase, and diaphorase (Durham et al., 1987) has been reported in peach leaves. Polymorphism also has been reported in peach pollen for isocitrate dehydrogenase, esterase, acid phosphatase, and malate dehydrogenase (Messeguer et al., 1987).

Isozyme alleles that could be used in mapping studies in peach or almond through interspecific hybridization are present in almond *(Prunus dulcis* Webb), *P. kansuensis* Rehd., *P. davidiana* (Carr.) Franch., and *P. mira* Koehne. Alleles for aspart ate aminotransferase (Arulsekar et al., 1986a; Hauagge et al., 1987), glucosephosphate isomerase (Arulsekar et al., 1986a; Hauagge et al., 1987; unpublished data), isocitrate dehydrogenase (Mowrey, unpublished data), leucine aminopeptidase (Andsekar et al., 1986a; Hauagge et al., 1987'; Mowrey, unpublished data), malate dehydrogenase (Arulsekar et al., 1986a), peroxidase (Mowrey, unpublished data), 6-phosphogluconate dehydrogenase (Arulsekar et al., 1986a; Mowrey, unpublished data), phosphoglucomutase (Arulsekar et al., 1986a; Hauagge et al., 1987; Mowrey, unpublished data), and shikimate dehydrogenase (Mowrey, unpublished data) differing from those present in peach have been reported within some of these species.

Isozyme banding patterns differ between stages of development and in various tissues in many organisms (Hancock and Iezzoni, 1988; Kruger and LaBerge, 1974; Kumar and Goswami, 1985; Market and Moller, 1959; Rajora and Zsuffa, 1986; Ramirez et al., 1987; Scandalios, 1964; Tanksley et al., 1981; Valpuesta and Bukovac, 1983). Tissue specific expression of isozymes may be considered a form of developmental expression, since tissue differentiation is governed by activation and deactivation of numerous genes governing development. Within *Prunus,* changes in indoleacetic acid oxidase (peroxidase) have been reported during fruit development in peach (Kumar and Goswami, 1985) and sour cherry *(P. cerasus* L.) (Valpuesta and Bukovac, 1983). Differential expression of malate dehydrogenase has also been' reported between pollen and leaf tissues of various cherry species (Hancock and Iezzoni, 1988).

Although changes in isozyme expression may be useful in developmental genetic studies, they can be a hindrance to plant breeders because uniform expression of isozymes throughout development would allow screening for isozyme variants at the seed or young seedling stage. Due to plant size and long juvenile periods of tree fruit species, this procedure would bring about considerable savings in time and space compared to

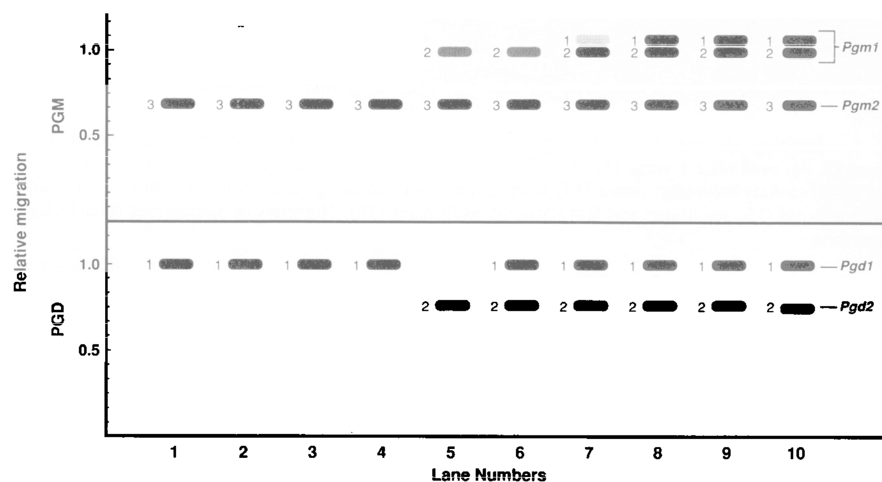

Fig. 1. Diagrammatic representation of banding patterns observed for phosphoglucomutase (PGM) and 6-phosphogluconate dehydrogenase (PGD) in dry (1) and imbibed seed (2); seed after 1 week (3), 1.5 months (4), 2.5 months (5), and 3 months (6) of stratification; cotyledon tissue (7) from 1-month-old seedling; leaf tissue of l-month- (8) and 3-month-old (9) seedlings; and leaf tissue of adult plant (10). Numbers in parentheses refer to lane numbers.

Received for publication 14 Nov. 1988. Paper no. 11906 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7601. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement solely* to indicate this fact.

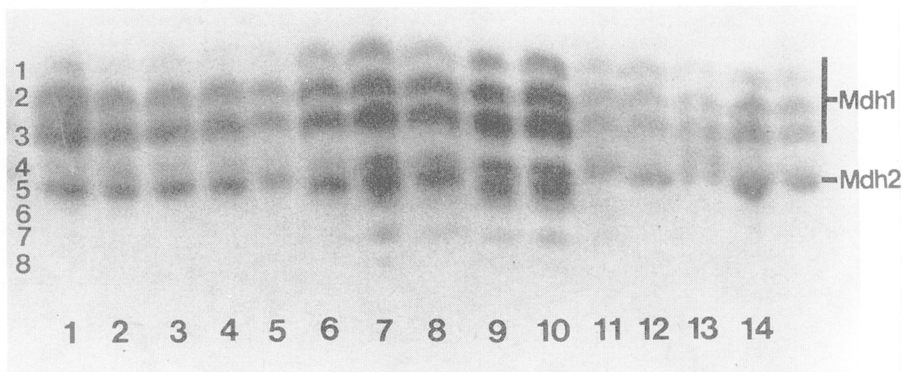

Fig. 2. Banding patterns observed for malate dehydrogenase (MDH) in dry (1) and imbibed seed (2); seed after 1 week (3, 4), 1.5 months (5, 6), 2.5 months (7, 8), and 3 months (9, 10) of stratification; cotyledon tissue (11) from l-month-old seedling; leaf tissue of l-month- (12) and 3-month-old (13) seedlings; and leaf tissue of adult plant (14). Numbers in parentheses refer to lane numbers.

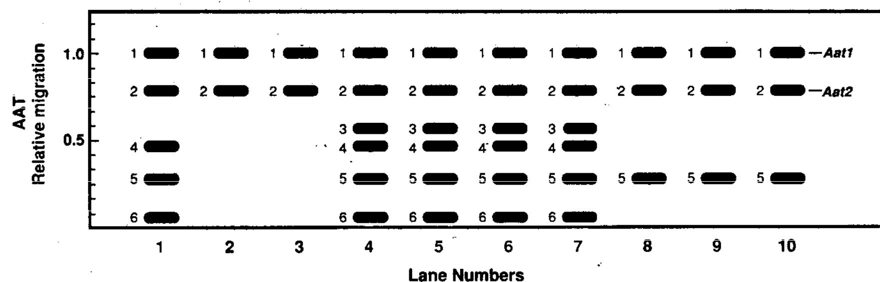

Fig. 3. Diagrammatic representation of banding patterns observed for aspartate aminotransferase (AAT) in dry (1) and imbibed seed (2); seed after 1 week (3), 1.5 months (4), 2.5 months (5), and 3 months (6) of stratification; cotyledon tissue (7) from l-month-old seedling; leaf tissue of l-month- (8) and 3-month-old (9) seedlings; and leaf tissue of adult plant (10). Numbers in parentheses refer to lane numbers.

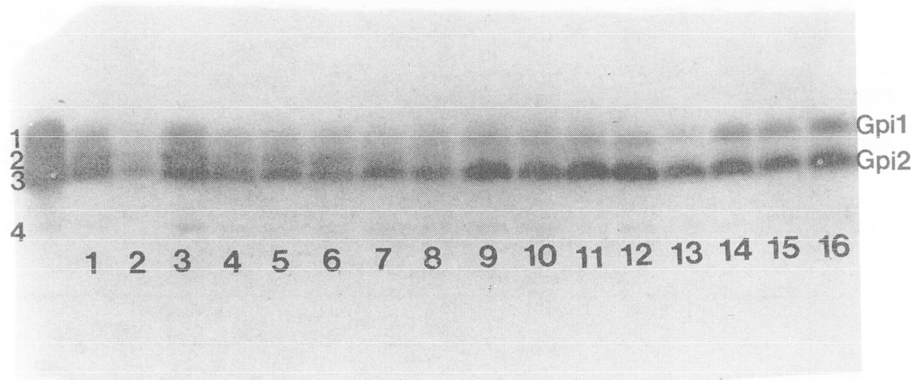

Fig. 4. Banding patterns observed for glucosephosphate isomerase (GPI) in dry (1, 2) and imbibed seed (3, 4); seed after 1 week (5, 6), 1.5 months (7, 8), 2.5 months (9, 10), and 3 months (11, 12) of stratification; cotyledon tissue (13) from l-month-old seedling; leaf tissue of l-month- (14) and 3-month-old (15) seedlings; and leaf tissue of adult plant (16). Numbers in parentheses refer to lane numbers.

screening adult plants. This study was conducted to determine if isozyme expression differed between various stages of development in peach and whether differential isozyme expression would interfere with isozyme screening at various developmental stages.

A doubled haploid derived from 'Rutgers Red-leaf' (RRL-2n) was used in the study so the progeny would be homozygous and homogeneous. Self-pollinated seed of RRL-2n were imbibed overnight in distilled H_2O and placed into stratification at varying intervals to allow sampling of genetically uniform material at various stages of development (Table 1). Seeds were stratified at 6 ± 1C in sealed petri dishes containing filter paper moistened with captan 50W solution (0.5 g·100 ml^{-1}). Following germination, seedlings were grown in flats in a greenhouse maintained at 24/20C (day/night). Leaf samples of adult material were obtained from rooted cuttings of RRL-2n maintained in the same greenhouse.

Electrophorectic techniques were as previously described (Mowrey et al., 1990a). The entire embryo, excluding testa, was used when sampling seed. Isozyme systems were surveyed using standard or slightly modified recipes and included alcohol dehydrogenase (ADH) (EC 1.1.1.1), aspartate aminotransferase (AAT) (EC 2.6.1.1), glucosephosphate isomerase (GPI) (EC 5.3.1.9), isocitrate dehydrogenase (IDH) (EC 1.1.1.41), malate dehydrogenase (MDH) (EC 1.1.1.37), phosphoglucomutase (PGM) (EC 2.7.5.1), 6-phosphogluconate dehydrogenase (PGD) (EC 1.1. 1.43), shikimate dehydrogenase (SDH) (EC 1.1. 1.25) (Stuber et al., 1988), peroxidase (PER) (EC 1.11.1.7) and leucine aminopeptidase (LAP) (EC 3.4.11.1) (Arulsekar and Parfitt, 1986). ADH, IDH, MDH, PGD, and SDH were stained on morpholine-citrate pH 6.1 gels (Conkle et al., 1982). AAT, GPI, LAP, and PER staining was performed on lithium-borate */tris* -citrate pH 8.3 gels (Stuber et al., 1988). PGM was stained on histidine-citrate pH 6.5 gels (Stuber et al., 1988).

Band migration distances were recorded to the nearest 0.5 mm. A relative migration (R_m was computed from the ratio of each isozyme band's migration to the migration of the fastest migrating band present in adult leaf samples within each enzyme system. Bands were numbered for identification from fastest to slowest migrating.

Differences in banding patterns and staining intensity of various bands were observed in most systems. Staining intensity of freshly imbibed seeds was generally less than that of dry seed and seed in stratification. This difference probably is due to dilution of native isozymes during imbibition that would be resynthesized after a period of stratification.

LAP was the only system not displaying differential expression between developmental stages. Two bands with Rm values of 1.00 and 0.74, corresponding to two loci (Arulsekar et al., 1986a; Hauagge et al., 1987), were detected in all samples when staining for LAP. SDH displayed no activity in seed until 2.5 months of stratification and later, when staining intensity neared that of adult leaf tissue. One band was detected in all samples when activity was present. IDH activity could not be scored in seed and cotyledon samples. PER activity was detected only in 3-month-old seedlings and adult leaf samples.

PGM and PGD behaved similarly in this study. Both systems are encoded by two loci in the subgenus *Amygdalus* (Arulsekar et al., 1986a; Chaparro et al., 1987;. Hauagge et al., 1987). PGM is monomeric; however, two bands are produced by the alleles of the *Pgm1* locus (Chaparro et al., 1987). In PGM and PGD, activity at only one locus could be detected until later stages of development. Good staining of *Pgm2* was obtained from all stages of development; however, activity at *Pgm1* was not detected until 2.5 months of stratification (Fig. 1). At this stage, and in seed exposed to 3 months of stratification, only the slow-migrating band of *Pgm1* could be detected. Both bands were detected in

Table 1. Stages of development examined for differential isozyme expression in peach.

Stage	Developmental stage
1	Dry seed
2	Imbibed seed
3	Seed after 1 week of stratificatic
4	Seed after 1.5 months of stratifi(
5	Seed after 2.5 months of stratifi(
6	Seed after 3 months of stratifica'
7	Cotyledon tissue from 1-month-(
8	Leaf tissue of 1-month-old seedl
9	Leaf tissue of 3-month-old seedl
10	Leaf tissue of adult plant

[z]Radicle emerged 1–2 mm.
[y]Radicle emerged ≈ 2 cm.

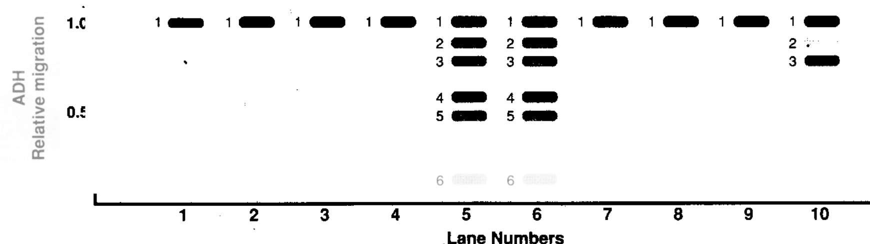

Fig. 5. Diagrammatic representation of banding patterns observed for alcohol dehydrogenase (ADH) in dry (1) and imbibed seed (2); seed after 1 week (3), 1.5 months (4), 2.5 months (5), and 3 months (6) of stratification; cotyledon tissue (7) from l-month-old seedling; leaf tissue of l-month- (8) and 3-month-old (9) seedlings; and leaf tissue of adult plant (10). Numbers in parentheses refer to lane numbers.

cotyledons of l-month-old seedlings; however, staining of the fast-migrating *Pgm1* band was fainter than in leaf samples. Similar results have been previously reported in cotyledons of peach × almond hybrids (Chaparro et al., 1987). No activity was detected at *Pgd2* until 2.5 months of stratification, but good staining of *Pgd1* was obtained before this stage (Fig. 1). At 2.5 months of stratification, no activity could be detected at *Pgd1*. Good staining was obtained at both PGD loci after 3 months stratification. In most plants, these enzymes are present in cytosolic and chloroplast specific forms (Gottlieb, 1981, 1982). Lack of staining at the *Pgm1* and *Pgd2* loci until commencement of germination may indicate that these loci produce chloroplast-specific enzymes because the seed lacked chlorophyll until this stage of development.

MDH is encoded by two loci in peach leaves with *Mdh1* polymorphic and *Mdh2* monomorphic (Arulsekar et al., 1986b; Durham et al., 1987; Mowrey et al., 1990a). RRL-2n is homozygous for the common *Mdh1* allele. Leaf samples from individuals homozygous for this allele produce a four-banded phenotype (Arulsekar et al., 1986b; Durham et al., 1987; Mowrey et al., 1990a). Eight bands were detected in the study with Rm values of 1.00, 0.90, 0.79, 0.67, 0.60, 0.54, 0.45, and 0.38 for bands 1 through 8, respectively (Fig. 2). Bands 1 through 3 were produced by *Mdh1,* while band 4 was produced by *Mdh2.* Bands 1 through 4 were the only bands present in leaf tissue. Band 5 was present in all seed samples. Bands 6 and 7 were present in dry seed and seed stratified for 2.5 and 3 months. Band 8 was present only in seed stratified for 2.5 and 3 months. MDH bands not present in leaf samples are present in zymograms of cherry pollen (Hancock and Iezzoni, 1982), and banding patterns obtained from peach pollen (Messeguer et al., 1959) differ from those reported in peach leaves (Arulsekar et al., 1986b; Durham et al., 1987; Mowrey et al., 1990a). Whether the additional bands present in pollen are homologous to those present in seed is not known.

Six bands with R_m values of 1.00, 0.79, 0.57, 0.47, 0.28, and 0.06 were detected in AAT (Fig. 3). Bands 1 and 2 were produced by *Aat1* and *Aat2,* respectively. Although AAT activity in leaf tissue is encoded by two loci (Arulsekar et al., 1986a; Hauagge et al., 1987), a third slow-migrating band (band 5) was detected in leaf tissue. This band was present in all samples, except for freshly imbibed seed and seed that had been stratified only 1 week. Band 5 is probably homologous to the faintly staining band previously reported near the origin (Hauagge et al., 1987; Mowrey et al., 1990b). Greenhouse conditions possibly were more conducive to expression of this enzyme than field conditions. Most plant species examined for AAT have three AAT loci (Gottlieb, 1981, 1982) and it is possible that band 5 is produced by an unreported third locus. Bands 1 and 2 were produced by *Aat1* and *Aat2,* respectively. We do not know why band 5 stained more intensely than previously reported (Hauagge et al., 1987; Mowrey et al., 1990b). Bands 4 and 6 were present in dry seed, seed after 2.5 and 3 months of stratification, and cotyledon tissue of l-month-old seedlings. Band 3 was detected in seed after 2.5 and 3 months of stratification and in cotyledon tissue of l-month-old seedlings.

GPI reportedly is encoded by two loci in leaf tissue (Arulsekar et al., 1986a; Hauagge et al., 1987). Four bands with R_m values of 1.00, 0.89, 0.83, and 0.63 were detected (Fig. 4). As with AAT, a band previously not reported was detected in leaf tissue. Bands 1, 3, and 4 were detected in all samples. Bands 1 and 3 were produced by *Gpi1* and *Gpi2,* respectively. Detection of band 4 in leaf tissue may be a result of growing the material in the greenhouse. Origin of band 4 is not known, since most plant species tested have only two GPI loci active in leaf tissue (Gottlieb, 1981). Band 2 was present in all seed samples, except for those stratified 3 months.

Inheritance of ADH has not been established in peach; however, two to three loci have been reported in other plant species (Gottlieb, 1981). ADH isozymes are cytoplasmic, and the products of various loci interact to form interlocks heterodimers (Gottlieb, 1981). Six bands with R_m values of 1.00, 0.88, 0.78, 0.58, 0.48, and 0.13 were detected when staining ADH activity (Fig. 5). Three loci probably are present in peach based on band number. Leaf samples stained considerably lighter than seed samples. All bands stained faintly and were difficult to photograph, except for band 1, which stained darkly in all seed samples. Band 1 was detected in all samples. Bands 2 and 3 were detected in seed after 2.5 and 3 months of stratification and in adult leaves, while bands 4, 5, and 6 were detected in seed only after 2.5 and 3 months of stratification. Fainter staining in leaf tissue may be related to the function of ADH in plant tissue. ADH is an inducible enzyme usually produced under anaerobic conditions or when tissues are exposed to stress (Mayne and Lea, 1984). Higher native levels of ADH are needed by seed tissue for anaerobic glycolysis (Gottlieb, 1981). Leaf tissue would not naturally experience anaerobic conditions and would not require high levels of the enzyme.

The presence of bands at various developmental stages not present in leaf tissue may indicate loci not active in leaves. Whether these possible loci are polymorphic in peach is not known. Although these presumed loci may provide peach breeders with more markers for genetic mapping, they could cause problems when screening for isozyme loci active in both seed and leaves. The additional MDH bands detected in seed tissue migrate in the same general region as bands produced in peach leaves from individuals possessing the slow *Mdh1* allele. Presence of these seed-specific bands could interfere with scoring the slow allele. Likewise, AAT bands 3 and 4 migrate in the same region as bands produced by the slow *Aat2* allele present in almond and P. kansuensis, and would interfere with screening for this allele. Additional bands present in GPI would not interfere with screening for known variants because bands 2 and 4 do not migrate in regions where previously reported alleles migrate.

The earliest time for complete screening

of the isozymes examined would appear to be 1 month following germination. Lack of activity at the *Sdh1, Idh1, Pgm1, Pgd2, Per1,* and *Per2* loci coupled with the presence of additional MDH and AAT bands makes screening of seed tissue impractical. PER screening cannot be accomplished until seedlings have grown for 3 months. ADH screening should be performed using seed tissue because staining in leaf tissue was inconsistent. Although isozyme screening cannot be accomplished until the young seedling stage for most systems, this would still result in considerable savings in time and space to the geneticist when compared with screening at the adult stage.

Literature Cited

Arulsekar, S. and D.E. Parfitt. 1986. Isozyme analysis procedures for stone fruits, almond, grape, walnut, pistachio, and fig. HortScience 21:928-933.

Arulsekar, S., D.E. Parfitt, and D.E. Kester. 1986a. Comparison of isozyme variability in peach and almond cultivars. J. Hered. 77:272–274.

Arulsekar, S., D.E. Parfitt, W. Beres, and P.E. Hansche. 1986b. Genetics of malate dehydrogenase isozymes in peach. J. Hered. 77:49-51.

Conkle, M. T., P.D. Hodgskiss, L.B. Nunnally, and S. C. Hunter. 1982. Starch gel electrophoresis of conifer seeds: A laboratory manual. U.S. Dept. Agr. Forest Service Gen. Tech. Rpt. PSW-64.

Chaparro, J. X., R. E. Durham, G.A. Moore, and W.B. Sherman. 1987. Use of isozyme techniques to identify peach × 'Nonpareil' almond hybrids. HortScience 22:300-302.

Durham, R. E., G.A. Moore, and W.B. Sherman. 1987. Isozyme banding patterns and their usefulness as genetic markers in peach. J. Amer. Soc. Hort. Sci. 112:1013-1018.

Gottlieb, L.D. 1981. Electrdphoretic evidence and plant populations. Prog. Phytochem. 7:1-47.

Gottlieb, L.D. 1982. Conservation and duplication of isozymes in plants. Science 216:373–380.

Hancock, A.M. and A.F. Iezzoni. 1988. Malate dehydrogenase isozyme patterns in seven *Prunus* species. HortScience 23:381–383.

Hauagge, R., D.E. Kestcr, and R.A. Asay. 1987. Isozyme variation among almond cultivars: I. Inheritance. J. Amer. Soc. Hort. Sci. 112:687-693.

Kruger, J.E. and D.E. LaBerge. 1974. Changes in peroxidase activity and peroxidase isozyme patterns of wheat during kernel growth and maturation. Cereal Chem. 51:345–354.

Kumar, S. and A.K. Goswami. 1985. Changes in peroxidase-IAA oxidase in developing peach fruit. Indian J. Plant Physiol. 28:331-336.

Mayne, R.G. and P.J. Lea. 1984. Alcohol dehydrogenase in Hordeum vulgare: Changes in isoenzyme levels under hypoxia. Plant Sci. Lett. 37:73-78.

Markert, C.L. and F. Moller. 1959. Multiple forms of enzymes: Tissue, ontogenetic, and species specific patterns. Biochem. 45:753-763.

Messeguer, K., P. Arus, and M. Carrera. 1987. Identification of peach cultivars with pollen isozymes. Scientia. Hort. 31:107-117.

Mowrey, B. D., D.J. Werner, and D.H. Byrne. 1990. Inheritance of isocitrate dehydrogenase, malate dehydrogenase, and shikimate dehydrogenase in peach and peach x almond hybrids. J. Amer. Soc. Hort. Sci. (In press.)

Mowrey, B. D., D.J. Werner, and D.H. Byrne. 1990. Isozyme survey of clones of *Prunus dulcis, P. kansuensis, P. davidiona, P. mira, P. persica* and *P. persica* subspecies Ferganensis. Scientia Hort. (In press.)

Rajora, O.P. and L. Zsuffa. 1986. Sporophytic and gametophytic gene expression in *Populus deltoides* Marsh., *P. nigra* and *P. maximowiczii* Henry. Can. J. Genet. Cytol. 28:476-482.

Ramirez, H., A. Hussain, W. Rota, and W. Bushuk. 1987. Isozyme electrophoregrams of 16 enzymes in five tissues of cassava *(Manihot esculenta* Crantz) varieties. Euphytica 36:39-48.

Scandalios, J.G. 1964. Tissue specific isozyme variation in maize. J. Hered. 55:281–285.

Stuber, C. W., J.F. Wendel, M.M. Goodman, and J.S.C. Smith. 1987. Techniques and scoring procedures for starch gel electrophoresis of enzymes from maize *(Zea mays* L.). North Carolina Agr. Res. Serv. Tech. Bul. 286.

Tanksley, S. D., D. Zamir, and C.M. Rick. 1981. Evidence for extensive overlap of sporophytic and gametophytic gene expression in *Lycopersicon esculentum.* Science 213:453-455.

Valpuesta, V. and M.J. Bukovac. 1983. Cherry fruit development: Indoleacetic acid oxidase isoenzymes in the seed. Physiol. Plant. 58:209–213.

HORTSCIENCE 25(2):222-223. 1990.

Greenhouse Disease Screen Facilitates Breeding Resistance to Tomato Early Blight

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Additional index words. *Altemaria solani, Lycopersicon esculentum, Lycopersicon hirsutum,* stem resistance, foliar resistance

Abstract. **An F_2 population segregating for tomato *(Lycopersicon esculentum* Mill.) early blight resistance derived from C1943 was screened in the greenhouse by spray-inoculating conidia of *Alternaria solani* (Ellis and Martin) Jones and Grout onto stems of 6-week-old seedlings. Selected F_3 lines derived from F_2 plants with resistant, intermediate, and susceptible stem lesion reactions were grown in a replicated field trial and evaluated for foliar early blight resistance. Stem lesion and foliar resistance were closely associated, making the greenhouse screen for stem lesion resistance useful in identifying plants with foliar resistance.**

Screening of tomato seedlings in the greenhouse for foliar resistance to early blight generally has not been successful. When selections with a moderate level of resistance were compared with susceptible lines, symptoms were not sufficiently different in most greenhouse tests to classify plants for level of resistance (Barksdale, 1969; Nash and Gardner, 1988a; O'Leary, 1985; Walker, 1983). In other studies, F_1 and early backcrosses of resistant PI 126445 *(Lycopersicon hirsutum* Humb. and Bonpl.) with susceptible *L. esculentum* lines showed sufficient resistance to be distinguishable from susceptible lines in greenhouse screening for foliar resistance (Gardner, 1984). However, as additional backcrosses and selection toward *L. esculentum* type were made, the resistance level became lower and greenhouse screening became more difficult.

Moderate levels of foliar resistance to early blight in the USDA line 71B2 (Barksdale and Stoner, 1977) and related lines (Barksdale and Stoner, 1973), in C1943 (Barksdale and Stoner, 1977), and in advanced selections from PI 126445 have been successfully screened in field plots (Barksdale, 1971; Kongpolprom, 1980; Maiero et al., 1989; Nash and Gardner, 1988a, 1988b; O'Leary, 1985; Shoemaker and Gardner, 1986; Walker, 1983). Replication and progeny testing have, however, been necessary in North Carolina to clearly distinguish and select for resistance in crosses with susceptible lines.

Andrus et al. (1942) identified a high level of resistance to the collar rot (basal stem lesion) phase of early blight in several tomato cultivars and selections and developed a greenhouse method of screening for resistance. They indicated that collar rot resistance was correlated with foliar resistance and suggested that selection for collar rot resistance should facilitate breeding for foliar resistance.

C1943, a tomato selection with a high level of stem lesion resistance and moderate foliar resistance to early blight (Barksdale and Stoner, 1977), has been used extensively in early blight resistance breeding in North

Received for publication 14 Dec. 1988. Paper no. 11915 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7601. Research supported in part by a grant from the North Carolina Tomato Growers Assn. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement solely* to indicate this fact.

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