Inter-relationship of Precocity, Prolificacy, and Percentage Kernel in Pecan

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Abstract. The inter-relationship of precocity, prolificacy, and kernel percentage was studied in pecan [*Carya illinoensis* (Wangenh.) C. Koch]. Prolificacy was highly correlated with precocity, but the relationship was not one to one. Increased precocity resulted in proportionately smaller increase in prolificacy. Variability in kernel percentage increased with prolificacy.

Establishment of a pecan orchard is a long-term and expensive venture. Under conditions of excellent culture, ≈ 10 years or more are required to produce yields that cover operating costs, while there may be 17 to 20 years before there is a net return on the orchard. Because of this high economical barrier to entry, much effort and expense has been expended to develop pecan cultivars that are precocious and prolific (Madden, 1974). However, precocious cultivars generally are less reliable as commercial cultivars. With few exceptions (e.g., 'Curtis'), most of the cultivars described by Reed (1912) as precocious or prolific have not proven, in the long-term, to be commercially reliable cultivars. In contrast, cultivars that were originally described as late to reach reproductive maturity (e.g., 'Pabst'), moderate producers (e.g., 'Schley' and 'Stuart'), or low producers (e.g., 'Van Deman') have proven to be reliable as mature trees. Two of these, 'Stuart' and 'Schley', are major cultivars of the industry. These observations suggest that planting of new precocious cultivars should be considered with caution until they are tested adequately as mature trees.

The reason precocious cultivars (Reed, 1912; Madden, 1974) are less reliable is their proneness to produce underdeveloped kernels once the tree begins to produce heavily (usually after 10 or more years of age). This poor quality results from an inadequate leaf area per fruit (Sitton, 1931). This report concerns the evaluation of the inter-relationships of precocity, prolificacy, and subsequent kernel quality.

All data were taken from the literature and were restricted to papers in which yields of cultivars included those of 'Stuart', the standard of the pecan industry (Thompson, 1984). Precocity and prolificacy were calculated as the ratio of yield of a given cultivar to that of 'Stuart'. Values less than one indicate precocity or prolificacy as being less than 'Stuart'; hence, values greater than one in-

dicate precocity or prolificacy greater than that of 'Stuart'. Precocity was calculated from yields of trees 10-years-old or younger, while prolificacy was calculated from yields of trees 11 years old or older. The range in tree age for the precocity calculation was from 4 to 10 years, whereas it was 11 to 51 years for prolificacy. In some papers, both precocity and prolificacy could be calculated from the same set of data, but often only one characteristic could be calculated from a given paper. Data were averaged by cultivar to

Fig. 1. Relationship between prolificacy and precocity in pecan: $Y = 0.1095 + 0.6807X$, $r = 0.9718$, $SE \pm 0.1054$. Regression coefficient is significantly different from zero, $P = 0.01$. AL = 'Alley', CU = 'Curtis', DE = 'Desirable', EL = 'Elliott', FA = 'Farley', FR = 'Frotscher', MA = 'Mahan', MM = 'Moneymaker', MO = 'Moore', NE = 'Nelson', PA = 'Pabst', SC = 'Schley', SU = 'Success', TE = 'Teche', and VD = 'Van Deman'. Precocity and/or prolificacy calculated from data of Assaf (1982), Alben et al. (1953), Blackmon (1932, 1935), Cole (1958), Dodge (1944, 1968), Fowler et al. (1933), Gossard (1963), Hunter (1951), Matthews (1929), Overcash and Kilby (1973), Skinner (1922, 1926), Stuckey and Kyle (1925), Wood (1982), Worley et al. (1983), Young (1968), and Young (1978).

minimize experimental errors arising from variable tree numbers, cultural practices, environmental conditions, etc. Variation in kernel development was expressed as the coefficient of variation of percentage kernel in the nut. The kernel percentages used to calculate the coefficient of variation were sometimes from the same papers as those used to calculate precocity and/or prolificacy, but often this was not the case. Data from 16 cultivars ('Alley', 'Curtis', 'Desirable', 'Elliott', 'Farley', 'Frotscher', 'Mahan', 'Moneymaker', 'Moore', 'Nelson', 'Pabst', 'Schley', 'Stuart', 'Success', 'Teche', and 'Van Deman') were available for this study.

Precocity was highly correlated ($r = 0.97$) with prolificacy (Fig. 1), indicating that a precocious cultivar will be prolific as a mature tree. The y intercept is near zero (0.11), but the regression coefficient (0.68) is less than unity. The regression coefficient is less than one because the difference between precocity and prolificacy becomes greater as precocity increases (Fig. 2); or, increased precocity results in a proportionately smaller increase in prolificacy. The increasing difference between precocity and prolificacy may reflect, with tree age, a progressive decrease in cluster size, a greater tendency to bear alternately, and/or a decrease in potential yield due to poor kernel development as precocity increases.

Variability in kernel development increased with prolificacy (Fig. 3), indicating that prolific cultivars do tend to be less reliable once the tree has matured. The less than unity correlation ($r = 0.84$) between kernel development and prolificacy undoubtedly reflects a degree of experimental error; however, more likely, the variation is due mainly to differences among cultivars in

Fig. 2. Precocity minus prolificacy as a function of precocity in pecan. Precocity minus prolificacy was calculated from the data in Fig. 1; $Y = -0.1095 + 0.3193X$, $r = 0.8842$, $SE \pm 0.1054$. Regression coefficient is significantly different from zero, $P = 0.01$. AL = 'Alley', CU = 'Curtis', DE = 'Desirable', EL = 'Elliott', FA = 'Farley', FR = 'Frotscher', MA = 'Mahan', MM = 'Moneymaker', MO = 'Moore', NE = 'Nelson', PA = 'Pabst', SC = 'Schley', SU = 'Success', TE = 'Teche', and VD = 'Van Deman'.

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Fig. 3. Variation in kernel development as a function of prolificacy in pecan; $Y = 1.0627 + 4.4659X$, $r = 0.8440$, $SE \pm 1.2684$. Regression coefficient is significantly different from zero, $P = 0.01$. AL = 'Alley', CU = 'Curtis', DE = 'Desirable', EL = 'Elliott', FA = 'Farley', FR = 'Frotscher', MA = 'Mahan', MM = 'Moneymaker', MO = 'Moore', NE = 'Nelson', PA = 'Pabst', SC = 'Schley', SU = 'Success', TE = 'Teche', and VD = 'Van Deman'. Coefficients of variation were calculated from data of Andrews et al. (1977), Assaf (1982), Blackmon and Ruprecht (1934), Burkett (1924, 1925), Calcote and Scott (1988), Cole (1950), Cross (1945), Dodge (1968), Gardner and Beaumont (1931), Gray (1974), Haulik and Holtzhausen (1988), Heaton (1969), Hunter (1951, 1964, 1967), Hunter and Hammar (1948, 1961), Hutchison (1949), Kays and Payne (1982), Large (1954), Large and Phillips (1950), Lutrick and Arnold (1973), Marshall and Ruprecht (1930), Nakayama (1967), O'Barr and Rachal (1987), Osburn (1958), Overcash (1970), Sherman and Gammon (1977), Sitton et al. (1932), Skinner (1922), Thompson and Hunter (1983), Winkler (1937), Wood (1982), Wood et al. (1980), Woodroof and Heaton (1961), Worley et al. (1983), Young (1968), and Young et al. (1973).

cluster size, nut size, and density of fruiting shoots. These factors would differentially affect the leaf area per unit of fruit and, thus, kernel development. Regardless of the reason(s), the variability in kernel development indicates that some cultivars are capable of producing more consistent quality at a given level of prolificness than are others. This relationship indicates that there may be limited leeway in a breeding program to develop a cultivar with relative high prolificness that will also produce acceptable quality kernels on a fairly consistent basis. The apparent low probability of this result occurring implies, until demonstrated otherwise, that highly precocious cultivars should be avoided for use in commercial pecan plantings. Observations suggest a cultivar should be tested 15 to 20 years before release.

Prolific cultivars tend to be undesirable unless the leaf area per fruit can be increased to an adequate level. Attempts to increase the leaf area per fruit by chemical fruit thin-

ning have not been successful (Sparks, 1986). Pruning increased percentage kernel in the nonprecocious 'Stuart', but total nut yield and marketable value were decreased (Worley, 1987). Pruning of precocious cultivars, such as 'Mahan' and 'Moore', may produce a response with a positive economic impact; however, at present, observations suggest that the most practical method to increase the leaf area per fruit is by increasing shoot length and thus leaf area (Sparks, 1966) by maintaining adequate soil moisture. Nevertheless, with very highly prolific cultivars, such as 'Moore' and 'Mahan', irrigation is only a partial solution.

Under existing cultural practices, precocious cultivars are often paradoxical-early yields produce an early economic return, but nut quality can be unacceptable as the tree approaches maturity. Perhaps a compromise is to plant a low precocity cultivar, such as 'Stuart', that has an upright and compact tree form more suited to a high-density orchard and which, in addition, produces acceptable yields of continued good quality as the tree matures. Cultivars with an upright compact growth habit would allow a higher tree density for a longer time interval than many precocious cultivars with a more spreading canopy. The increased tree number would minimize the negative effect of low precocity.

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