Fruit Varieties Journal 45(4):238-241 1991

Dry Matter Partitioning in 'Starkspur Supreme Delicious' on Nine Rootstocks

DALE STRONG[1] AND ANITA MILLER-AZARENKO[2]

Abstract

The dry matter partitioning to vegetative and reproductive components of 'Starkspur Supreme' on 9 rootstocks in the 1980-81 NC-140 apple rootstock trials was determined in 1990. Trees on MAC.24 and M.7 EMLA had the heaviest aboveground dry weight and the lowest harvest index (HI); M.26 EMLA trees were intermediate for both. 'Starkspur Supreme' on OAR 1, O.3, M.9 EMLA, M.9, MAC.9 , and M.27 EMLA accumulated the least dry matter and had the highest HI's. Total aboveground dry weight in March ranged from 40.8 kg for MAC.24 to 1.5 kg for M.27 EMLA. HI's ranged from a high of 0.55 for M.27 EMLA to 0.36 for MAC.24. Trees with less aboveground dry weight partitioned a higher percentage of their total to spurs and spur leaves. The percent of spur dry weights ranged from 8.1 for M.27 EMLA to 2.1 for MAC.24. Spur leaf dry weight percentages ranged from 6.0 for M.27 EMLA to 2.7 for MAC.24.

Additional index words. Malus x domestica, harvest index.

Introduction

Tree growth involves the accumulation of biomass and its partitioning to various parts of the tree. Many researchers have evaluated the effects of rootstocks on growth of specific components such as flowers, fruit, leaves, roots, and shoots, but few have examined the effects on total biomass and dry matter partitioning characteristics of apple trees. Forshey (4) determined the partitioning of dry matter by 'McIntosh' apple trees on MM.106 rootstocks and reported the total dry weight and percent composition for different growth components.

The 1980-81 NC-140 apple rootstock evaluation trial provided an opportunity for measurement of dry matter accumulation in the different aboveground parts of trees on 9 apple rootstocks.

Materials and Methods

The test trees were planted with 5 replicates each in 1980 and 1981 at the Oregon State University Lewis-Brown Farm near Corvallis, Oregon. The rootstocks evaluated with 'Starkspur Supreme Delicious' as the scion cultivar were MAC.24, OAR 1, M.7 EMLA, M.26 EMLA, O.3, M.9 EMLA, M.9, MAC.9, and M.27 EMLA. Each year, trees were planted in five replicate rows at a spacing of 3.5 x 5.5 m with two additional pollinizer rows of 'Macspur' and 'Starkspur Golden Delicious' on M.26 EMLA. Trees were trained to modified central leader. The soil type was a silty clay loam. A 1.5 m herbicide strip was maintained with red fescue between the rows. Irrigation was provided by low head sprinklers. Trees were winter pruned in February 1990 as in previous years. Fruit were not thinned during the 1990 growing season. Other data on growth and production of trees in the trial have been reported (6).

Mortality and atypical growth eliminated some trees from the study, leaving 8 replicates of each rootstock. Trees of each rootstock were first ranked according to trunk cross-sectional

Received for publication . Oregon Agricultural Experiment Station Technical Paper No. 9692. Special thanks to Ms. Viki Freeman, Scott Robbins, Willie Moeller, Jim Plunkett, and Gary Horton for their technical assistance.

[1]Graduate Research Assistant, Department of Horticulture, 2042 Cordley Hall, Oregon State University, Corvallis, OR 97331-2911.

[2]Assistant Professor, Department of Horticulture, 2042 Cordley Hall, Oregon State University, Corvallis, OR 97331-2911.

area (TCSA). Based on the relationship between TCSA and total aboveground tree biomass (11), two similar trees were paired and 4 replicate pairs were formed. One tree of each replicate pair was destructively sampled in March 1990 and the other in October/November 1990. In March, aboveground portions were fractioned into 1- and 2-year wood, spurs, and frame, then fractions were dried at 60°C and weighed. In early October, fruit was harvested and weighed, with 50 fruit samples from each tree weighed and stored for later analysis. Current season's growth was then removed and stripped of shoot leaves. Trees were then fractioned into spur leaf, 1- and 2-year wood, spurs, and frame, and all fractions except fruit dried at 60°C and weighed. Subsamples of 10 fruit from each tree were dried at 30°C for 4 days then increased to 60°C until dry. Total fruit dry weight per tree was then estimated from the subsample dry weights. No attempt was made to account for loss due to fruit and leaf drop.

Data were analyzed by the general linear model (GLM) procedure of Statistical Analysis Systems (SAS) (8). An arcsin square root transformation was performed on percent data prior to analysis and means separation by the Waller-Duncan k-ratio t-test, k-ratio = 100. Data in tables are non-transformed means of the 4 replicates at each sampling data.

Results and Discussion

Of the trees analyzed in March 1990, MAC.24 was the heaviest, followed by M.7 EMLA and M.26 EMLA (Table 1). Dry weight of trees on O.3, OAR 1, M.9 EMLA, MAC.9, and M.9 did not differ in aboveground dry weight. M.27 EMLA had the least aboveground dry weight, although not significantly less than M.9 and MAC.9. Similar trends for vegetative, fruit, and aboveground tree dry weight were observed in October/November, although MAC.24 and M.7 EMLA were not significantly different. M.27 EMLA had the lowest total fruit dry weight. OAR 1, O.3, M.9 EMLA, M.9, and MAC.9 had comparable fruit dry weights per tree, followed by M.26 EMLA, while fruit dry weight per tree was the heaviest for MAC.24 and M.7 EMLA.

Percentages of the total aboveground dry weight of different fractions provide a comparison of the partitioning characteristics of trees on each rootstock (Tables 2 and 3). In general, as tree size decreased, a higher percentage of the dry weight was in spurs, spur leaves, and fruit. There was a

Table 1. Dry weights (kg) of fruit and aboveground vegetative growth in March and October/November 1990 of the NC-140 'Starkspur Supreme Delicious.'[z]

	Dry weight (kg)			
	March	October-November		
Rootstock	Vegetative[y]	Vegetative	Fruit	Total
MAC.24	40.75 a	45.92 a	24.94 a	70.86 a
OAR 1	9.04 d	9.66 c	8.09 c	17.75 c
M.7 EMLA	31.64 b	42.53 a	23.11 a	65.64 a
M.26 EMLA	20.03 c	24.39 b	16.20 b	40.59 b
O.3	9.16 d	10.02 c	10.22 c	20.24 c
M.9 EMLA	8.51 d	10.36 c	10.14 c	20.50 bc
M.9	5.47 de	7.56 c	7.72 c	15.28 cd
MAC.9	6.29 de	6.09 c	6.75 c	12.84 cd
M.27 EMLA	1.49 e	1.34 c	1.69 d	3.03 d

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100. Means were of 4 replications.
[y]Vegetative = leaves (spur and shoot) + (spur, current, 1-yr., 2-yr., and frame), when applicable.

Table 2. Percentage of total aboveground dry weights of the spurs, one and two-year wood, and frame in March 1990 of the NC-140 'Starkspur Supreme' apple trees grafted onto nine rootstocks.[z]

	Wood			
Rootstock	Spur	1-yr	2-yr	Frame
MAC.24	2.5 e	2.9 a	5.4 ab	89.2 a
OAR 1	7.5 bc	1.5 bc	4.4 b	86.6 bc
M.7 EMLA	2.8 e	2.9 a	5.5 ab	88.8 ab
M.26 EMLA	3.9 de	2.2 ab	6.2 ab	87.7 abc
O.3	7.1 c	2.5 ab	7.6 a	82.8 e
M.9 EMLA	5.1 d	2.4 ab	5.9 ab	86.6 bc
M.9	7.6 bc	1.5 bc	5.4 ab	85.5 cd
MAC.9	9.4 ab	2.2 ab	5.9 ab	82.5 e
M.27 EMLA	10.0 a	0.8 c	5.9 ab	83.3 de

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100 of arcsine square root transformed data. Means were of 4 replications.

highly significant negative correlation between percent spur and total aboveground dry weight (r^2 = -0.66), spur leaf and the total aboveground dry weight (r^2 = -0.28), and fruit and the total aboveground dry weight (r^2 = -0.24). MAC.24 and M.7 EMLA had the highest percentage of dry weight in current season's growth and were also high in 1-and 2-year wood, frame, and shoot leaf. M.27 EMLA was highest in percent spur, spur leaf, and fruit, while MAC.9, M.9, M.9 EMLA, O.3, and OAR 1 were also high in these fractions. While there is some evidence that trees on M.9 EMLA produce more vegetative growth than trees on M.9, they were not significantly different.

Trees on M.27 EMLA had the highest percentage of dry weight in fruit (highest HI), followed by MAC.9, M.9, O.3, M.9 EMLA, OAR 1, M.26 EMLA, M.7 EMLA, and MAC.24 (Table 3). Values ranged from 54.7% in M.27 EMLA to 35.5% in Mac.24. Working with larger trees ('McIntosh/MM 106'), Forshey (4) found lower percentages partitioned to fruit (18.3), spurs (0.6), and spur leaves (3.9) than any of the rootstocks in this study, while wood components (70.5) and shoot leaves (6.7) were higher. While general parti-

Table 3. Percentage of total aboveground dry weights in October/November 1990 of the NC-140 'Starkspur Supreme' apple trees grafted onto nine rootstocks.[z]

		Leaves		Wood				
Rootstock	Fruit[y]	Spur	Shoot	Spur	Current	1-yr	2-yr	Frame
MAC.24	35.5 d	2.7 e	2.6 c	2.1 c	1.8 a	3.1 a	4.5 a	47.7 a
OAR 1	45.6 bc	5.8 a	0.4 d	4.5 b	0.3 cd	0.9 d	2.7 cde	39.8 de
M.7 EMLA	35.9 d	3.2 de	2.7 a	2.6 c	1.8 a	2.9 a	4.2 b	46.5 a
M.26 EMLA	41.8 cd	3.9 cd	2.1 ab	4.3 b	1.0 b	1.6 bc	3.5 abc	41.8 ab
O.3	50.9 ab	5.2 ab	1.1 c	4.1 b	0.4 cd	2.1 ab	3.2 abc	33.0 bc
M.9 EMLA	49.4 ab	4.2 bc	1.3 bc	4.1b	0.6 bc	1.4 bc	3.8 abc	35.2 cd
M.9	51.0 ab	5.0 ab	0.7 cd	5.0 b	0.2 d	1.1 cd	2.9 bcd	34.1 d
MAC.9	53.3 a	5.3 a	0.8 cd	5.2 b	0.3 cd	0.6 d	1.9 de	32.6 de
M.27 EMLA	54.7 a	6.0 a	0.4 d	8.1 a	0.5 c	0.5 d	1.7 e	28.0 e

[z]Means separation by Waller-Duncan k-ratio t-test. k-ratio = 100 arcsine square root transformed data. Means were of 4 replications.
[y]Same as harvest index (x100).

tioning trends are suggested, it is impossible to predict how other cultivars would respond on the same rootstocks.

Vegetative dry weight data generally parallel observations of rootstocks with respect to level of vigor control of the scion (8). If trees are classed based on the partitioning characteristics of the rootstocks, MAC.24 and M.7 EMLA would be placed in a high vegetative growth category, followed by M.26 EMLA. In this planting, OAR 1, O.3, M.9 EMLA, and M.9 would represent a third group. The last category, rootstocks which also induced the highest HI, would be typified by M.27 EMLA and MAC.9.

Although mechanisms of dwarfing are not fully understood, research has demonstrated that as fruiting increases, growth of vegetative components decreases (1, 3, 5, 7, 10). Competition for available photosynthate has been suggested as a possible explanation for this response (2) since a higher percentage of photosynthate partitioned to fruit means less available for vegetative growth. however, differences in rootstock response have been observed prior to the onset of fruiting and also in years of total crop loss. It is more likely that cropping can affect vegetative growth within a range genetically determined by the rootstock.

Literature Cited

1. Avery, D. J. 1970. Effects of fruiting on the growth of apple trees on four rootstock varieties. New Phytol. 69:19-30.
2. Beakbane, A. B. 1956. Possible mechanisms of rootstock effect. Ann. Appl. Biol. 44:517-521.
3. Forshey, C. G. and M. W. McKee. 1970. Production efficiency of a large and small 'McIntosh' apple trees. HortScience 5:164-165.
4. Forshey, C. G., R. W. Weiress, B. H. Stanley, and R. C. Sem. 1983. Dry weight partitioning of 'McIntosh' apple trees. J. Amer. Soc. Hort. Sci. 108:149-154.
5. Maggs, D. H. 1963. The reduction in growth of apple trees brought about by fruiting. J. Hort. Sci. 38:119-128.
6. Rogers, W. S. and G. A. Booth. 1964. Relationship of crop and shoot growth in apples. J. Hort. Sci. 39:61-65.
7. Rom, R. C. and R. F. Carlson. 1987. Rootstocks for fruit crops. John Wiley & Sons, New York, NY.
8. SAS Institute, Inc. 1985. SAS User's Guide: Statistics, version 5 edition. Cary, NC.
9. Warrington, I. J., D. C. Ferree, J. R. Schupp, F. G. Dennis, Jr., and T. A. Baugher. 1990. Strain and rootstock effects on spur characteristics and yield of 'Delicious' apple strains. J. Amer. Soc. Hort. Sci. 115:348-356.
10. Westwood, M. N. and A. N. Roberts. 1970. The relationship between trunk cross-sectional area and weight of apple trees. J. Amer. Soc. Hort. Sci. 95:28-30.

Apple Cultivar Performance on a Dwarfing Rootstock Under Drought

A study at East Malling of 15 cultivars on M.27 rootstock with drought imposed by tents under the trees showed that 'James Grieve' consistently had the highest leaf conductances and lowest leaf water potentials. Drought decreased growth much more than it decreased fruit yield. Yield was reduced on all cultivars except 'Egremont Russet,' 'Gravenstein' and 'Wagener' mainly as a reduction in number of fruit. Although lower yields of 'Falstaff' and 'Suntan' were due to smaller fruit. 'James Grieve' and 'Jester' under irrigated conditions had the most fully open stomates and 'Wagener' and 'Cornish Gillyflower' had the lowest conductance indicating the most closed stomates. The highest leaf water potentials were found in *Malus robusta*, 'French Crab' and 'Suntan' with the lowest in 'James Grieve' and 'Jupiter.' Although clear differences in water relations of apple scion cultivars are shown, the magnitudes of the differences are small and their role in drought tolerances unclear.

From Higgs and Jones. 1991. *J. Hort. Sci.* 66:367-379.