

Research Article



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M.7 및 M.9에 접목된 ‘산사’ 사과나무의 대목 노출 길이가 영양생장 및 생산량에 미치는 영향

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Influence of the Exposed Length of Rootstock on Vegetative Growth and Productivity of ‘Sansa’ Apple Trees Grafted on M.7 or M.9

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Abstract

M.7 rootstock is moderately resistant to fire blight. However, M.7 is generally too vigorous for high-density apple systems, but it can be grafted onto cultivars that exhibit weak tree growth, such as ‘Sansa’. This study investigated the vegetative growth, yield, and fruit quality of ‘Sansa’ apple trees grafted on M.7 or M.9 rootstocks to assess the feasibility of establishing domestic high-density apple systems using M.7 and to determine the optimum exposure length for rootstocks. Trees were planted with exposed rootstock lengths of 5, 10, and 15 cm. The vegetative growth of apple trees grafted onto M.7 was greater than that of M.9 and vegetative growth tended to decrease as the exposed length of rootstock increased. However, the differences in yield per

tree, average weights, soluble solids contents, and titratable acidity due to the rootstock and its exposure length varied. The accumulated yield over a 10 year period and the yield efficiency of M.7 were lower than that of M.9 and the yield efficiency tended to decrease as the exposed length of rootstock increased. When apple trees were grafted onto M.9, biennial bearing and tree vigor weakening occurred if the exposed length of the rootstock was over 10 cm. Conversely, when apple trees were grafted onto M.7, vegetative growth was excessive if the exposed length of rootstock was below 10 cm. Based on the results from this study, the optimum M.7 and M.9 exposure lengths for ‘Sansa’ were 15 cm and 5 cm, respectively.

Key words: Accumulated yield, Biennial bearing, Fire blight, Vegetative growth, Yield efficiency

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서론

(*Malus domestica* Borkh.) 8 가 [1,2], 200 g [3]. [4]. [5,6], [7-9]. M.9 M.26 [6,10], M.9 M.26 (swelling) M.9 () 2015 M.9 [11]. 가 [12], M.9 M.7 M.26 [7], 가 30% 가 [13]. 가 [2, 11] 가 M.7 [7,8] [4,5,7] M.7 가 [6,14], 가 가 [5,7,8], [15]. [16]. M.9 10 cm 10-20 cm 가 가 [10,16,17].

/M.7

M.7

M.9 (5 cm, 10 cm, 15 cm) 7 (2016 2022)

재료 및 방법

시험재료 및 관리 방법

7 (2016 2022) 2015 12 3.5 m 0.8 m 10 a 3 , 100 kg 2016 3 M.7 M.9 ' ' 2 (2.0 m , 5 cm 40.0 mm , 30 cm 가 10) 3.5 × 1.5 m (10 a 190) (5 cm, 10 cm, 15 cm) (2710ARL, Soil moisture equipment Corp., USA) (4~10) -50 kPa 가 9 1 4 가 3.5 m (tall spindle) [18], 2 7 (N:P:K=21:17:17) 3 2 100 g 2 5-6 1 , 2 9 , 6 1-2 가 가 1 (M.7, M.9) (5 cm, 10 cm, 15 cm) 3 (18) 7

영양생장

(trunk cross-sectional area. TCA) (11 12) . TCA 5 cm 2 1/3πr²h (r= , h = -) [18], 가 가

4 (2019)
가 3.0 cm

10 a당 누적 과실 생산량 및 수량효율
10 a
10 a (190) (ton)
(yield efficiency)
TCA (cm²) [6,18,20].

과실의 생산량 및 품질
2 8

통계분석
SAS 9.2 0.05, 0.01,
0.001 2 (,)
0.05 T-test Duncan test

(Chroma meter CR-400, Konica minolta, Japan) 3 1 1 3

Hunter's a 가

결과 및 고찰

영양생장
(TCA) 7 (1 7
M.7 M.9
1 가 2 7
5 cm TCA가 15 cm

Table 1. Trunk cross-sectional area (TCA) according to the exposed length of rootstock in the 'Sansa' apple trees grafted on M.7 or M.9 for 7 years

Treatments	TCA (cm ²)						
	Years after planting						
	1	2	3	4	5	6	7
M.7 - 5 cm	14.1 a ^z	33.1 a	51.3 a	66.5 a	77.0 a	89.7 a	102.2 a
M.7 - 10 cm	13.4 ab	31.2 ab	49.7 a	65.0 a	74.1 a	86.6 ab	98.5 ab
M.7 - 15 cm	12.9 abc	26.5 bc	44.4 ab	57.2 ab	66.2 ab	78.0 b	90.4 b
M.9 - 5 cm	11.6 abc	23.3 cd	38.8 bc	47.9 bc	59.9 b	62.8 c	66.8 c
M.9 - 10 cm	10.3 bc	20.4 de	35.4 c	45.8 c	55.4 b	60.2 c	63.1 c
M.9 - 15 cm	9.7 c	16.9 e	23.3 d	30.7 d	39.3 c	48.1 d	59.8 c
Rootstock (A)							
M.7	13.5 a ^y	30.3 a	48.5 a	62.9 a	72.4 a	84.8 a	97.0 a
M.9	10.5 b	20.2 b	32.5 b	41.5 b	51.5 b	57.0 b	63.2 b
Exposed length of rootstock (B)							
5 cm	12.9 a ^z	28.2 a	45.1 a	57.2 a	68.5 a	76.3 a	84.5 a
10 cm	11.9 a	25.8 a	42.6 a	55.4 a	64.8 a	73.4 a	80.8 ab
15 cm	11.3 a	21.7 b	33.9 b	44.0 b	52.8 b	63.1 b	75.1 b
ANOVA ^x							
Rootstock (A)	*	***	***	***	***	***	***
Exposed length (B)	NS	**	**	**	**	**	*
A x B	NS	NS	NS	NS	NS	NS	NS

^z Means followed by the same letter are not significantly different using Duncan's multiple range test, $P \leq 0.05$.

^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

TCA 7 M.7 - 5 cm M.7 - 5 cm M.7 - 10 cm
M.7 - 10 cm TCA가 M.9 - 15 cm M.9 - 15 cm , M.7
, M.7 - 15 cm TCA 1 5 - 15 cm M.9 - 5 cm
M.9 - 5 cm 가 , TCA 가 ,
7 7 (Table 3).
(Table 1). M.7 M.9
, 7 M.7 M.9 가 , , TCA [7,8,13],
, 1 6 [2,10,15,16] . 7 M.7
5 cm 15 cm TCA, M.9 ,
7 M.7 - 5 cm 가 TCA,
M.7 - 10 cm M.9 - 15 cm (Tables 1-3).
, M.7 - 15 cm M.9 - 5
cm M.9 - 10 cm 가 , 3-4 [5], (: 3.7 m,
7 : 6.7 x 4.3 m) ' /M.7 10 TCA
(Table 2). 56.7 cm², 9.4 m³ [21],
(: 3.5 m, : 4.0 x 0.6 m) ' /
4 , M.9 5 3.21 m³ [22],
M.7 M.9 3.5 m (4.0 x 2.0
, 1 3 m) ' /M.9 8 TCA가 48.9 cm²
5 cm 15 cm [23]가 . 2
. 4 M.9 - 15 cm

Table 2. Canopy volume according to the exposed length of rootstock in the ‘Sansa’ apple trees grafted on M.7 or M.9 for 7 years

Treatments	Canopy volume (m ³)						
	Years after planting						
	1	2	3	4	5	6	7
M.7 - 5 cm	5.41 a ^z	9.70 a	12.09 a	12.51 a	14.52 a	14.01 a	10.21 a
M.7 - 10 cm	5.03 a	8.27 ab	11.27 ab	9.76 ab	12.28 ab	11.47 ab	8.29 ab
M.7 - 15 cm	4.46 ab	6.92 bc	8.24 abc	9.27 ab	11.00 ab	7.98 b	7.05 abc
M.9 - 5 cm	4.35 ab	5.46 cd	8.31 abc	8.79 abc	10.36 ab	10.46 ab	4.93 bc
M.9 - 10 cm	3.35 bc	4.99 cd	7.17 bc	7.15 bc	7.05 bc	7.77 bc	3.95 bc
M.9 - 15 cm	2.62 c	3.60 d	5.36 c	5.32 c	5.14 c	4.27 c	3.26 c
Rootstock (A)							
M.7	4.97 a ^y	8.30 a	10.53 a	10.51 a	12.60 a	11.15 a	8.52 a
M.9	3.44 b	4.68 b	6.95 b	7.09 b	7.52 b	7.50 b	4.05 b
Exposed length of rootstock (B)							
5 cm	4.88 a ^z	7.58 a	10.20 a	10.65 a	12.44 a	12.24 a	7.57 a
10 cm	4.19 ab	6.63 a	9.22 ab	8.46 ab	9.67 ab	9.62 b	6.12 a
15 cm	3.54 b	5.26 b	6.80 b	7.30 b	8.07 b	6.13 c	5.16 a
ANOVA ^x							
Rootstock (A)	**	***	**	**	***	**	**
Exposed length (B)	*	**	*	*	*	***	NS
A x B	NS	NS	NS	NS	NS	NS	NS

^z Means followed by the same letter are not significantly different using Duncan’s multiple range test, $P \leq 0.05$.

^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 3. Average shoot growth according to the exposed length of rootstock in the 'Sansa' apple trees grafted on M.7 or M.9 for 7 years

Treatments	Average shoot length (cm)						
	Years after planting						
	1	2	3	4	5	6	7
M.7 - 5 cm	57.7 a ^z	33.0 a	28.3 a	-	33.9 a	32.0 a	35.7 a
M.7 - 10 cm	55.0 ab	32.6 a	26.7 a	-	33.2 a	28.7 ab	34.3 ab
M.7 - 15 cm	47.7 bc	30.5 a	23.5 abc	-	28.9 ab	27.1 ab	29.0 abc
M.9 - 5 cm	39.2 cd	30.0 a	24.5 ab	-	26.4 ab	22.3 bc	27.3 bc
M.9 - 10 cm	34.2 d	25.0 ab	18.6 bc	-	24.1 bc	19.0 c	25.2 bc
M.9 - 15 cm	30.1 d	19.2 b	17.3 c	-	23.1 c	18.5 c	22.5 c
Rootstock (A)							
M.7	53.5 a ^y	32.0 a	26.2 a	-	32.0 a	29.3 a	33.0 a
M.9	34.5 b	24.7 b	20.1 b	-	24.5 b	19.9 b	25.0 b
Exposed length of rootstock (B)							
5 cm	48.5 a ^z	31.5 a	26.4 a	-	30.2 a	27.2 a	31.5 a
10 cm	44.6 ab	28.8 a	22.7 ab	-	28.7 a	23.9 a	29.8 a
15 cm	38.9 b	24.9 a	20.4 b	-	26.0 a	22.8 a	25.8 a
ANOVA ^x							
Rootstock (A)	***	*	**	-	***	***	**
Exposed length (B)	*	NS	*	-	NS	NS	NS
A x B	NS	NS	NS	-	NS	NS	NS

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^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

1 3.35 m³, 4 TCA가 45.8 과실의 생산량 및 품질
 cm², M.7 TCA
 4 57.2 cm², 9.27 m³, 6 M.7
 (Tables 1, 2), [21-23] 가 M.9 가
 1, 4, 6 (2 7
 , M.7) 가 .
 TCA [21] 10 TCA 6 M.9 - 10 cm M.9 - 15 cm
 가 (Tables 1, 2). 가
 가 6
 [11]. (Table 4).
 가 [14,
 20], 30 cm , 2 5 M.7
 가 , 20 cm 가 가 M.9 6
 [20,24,25]. M.7 - 5 cm, M.7 - 10 cm M.7 M.9 , 가
 (5) 30 cm 5
 가 M.7 - 15 cm M.9 - 5 cm 10 cm 15 cm 5 cm
 3 30 cm 가 .
 , M.9 - 10 cm 3, 6 , M.9 - 15 2 7
 cm 2, 3, 6 20 cm 가 3 M.7 - 10 cm
 가 (Table 3). , M.7 - 5 cm M.7 - 10 cm M.9 - 5 cm , 4
 가 , M.9 - 10 cm M.9 - 15 cm M.7 - 10 cm 가 M.9 - 10 cm
 가 (Tables 1-3). , 5 M.7 M.9 - 10 cm

Table 4. Number of fruit per tree according to the exposed length of rootstock in the ‘Sansa’ apple trees grafted on M.7 or M.9 for 6 years

Treatments	Number of fruit per tree (ea)					
	Years after planting					
	2	3	4	5	6	7
M.7 - 5 cm	43 a ^z	56 a	59 a	88 a	92 a	103 a
M.7 - 10 cm	42 a	56 a	50 a	97 a	92 a	101 a
M.7 - 15 cm	54 a	55 a	62 a	103 a	93 a	108 a
M.9 - 5 cm	41 a	60 a	60 a	100 a	84 a	109 a
M.9 - 10 cm	48 a	56 a	74 a	114 a	70 b	110 a
M.9 - 15 cm	40 a	53 a	60 a	115 a	65 b	111 a
Rootstock (A)						
M.7	46 a ^y	56 a	57 a	96 a	92 a	104 a
M.9	43 a	56 a	65 a	110 a	73 b	110 a
Exposed length of rootstock (B)						
5 cm	42 a ^z	58 a	60 a	94 a	88 a	106 a
10 cm	45 a	56 a	62 a	106 a	81 a	106 a
15 cm	47 a	54 a	61 a	109 a	79 a	110 a
ANOVA ^x						
Rootstock (A)	NS	NS	NS	NS	***	NS
Exposed length (B)	NS	NS	NS	NS	NS	NS
A x B	NS	NS	NS	NS	NS	NS

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^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

M.9 - 15 cm . 6 3 5 가 , 3
M.7 - 15 cm M.9 - 15 cm M.7 - 5 cm M.7 - 10 cm 가
. , M.9 - 10 cm , 5
6 (Table 5). M.7 - 15 cm 가 M.9
. , 가
, 2 4 6 (Table 7).
M.7 M.9
5 7 가 , 2 5 가
6 가 . , 2 M.7 M.9
5 7 가 2 5 M.7 M.9 .
M.7 - 5 cm M.7 - 10 cm 6 가 .
M.9 - 5 cm , 3 M.7 - 10 2, 5, 6 가
cm 가 M.9 - 15 cm , 4 , 2 M.7 - 5 cm
M.7 - 5 cm M.7 - 10 cm M.9 - 5 cm M.9 - 15 cm , 5
M.9 . 6 M.7 - 5 cm M.7 - 15 cm 가 M.9
M.7 - 10 cm M.9 - 10 cm , 6 M.7 - 10 cm 가 M.9 - 5 cm
. ,
6 (Table 6). 6 (Table 8).
가
, 3, 5, 7 M.7 , 6 M.7
가 M.9 가 M.9 , 6
6 가 가 4 5

Table 5. Yield per tree according to the exposed length of rootstock in the 'Sansa' apple trees grafted on M.7 or M.9 for 6 years

Treatments	Yield per tree (kg)					
	Years after planting					
	2	3	4	5	6	7
M.7 - 5 cm	7.9 a ^z	8.1 ab	12.1 ab	17.9 c	20.3 ab	23.9 a
M.7 - 10 cm	7.6 a	7.7 b	10.3 b	21.1 bc	21.0 ab	23.5 a
M.7 - 15 cm	10.2 a	8.6 ab	13.2 ab	21.6 bc	21.9 a	25.3 a
M.9 - 5 cm	8.5 a	9.6 a	13.6 ab	22.2 b	20.2 ab	25.1 a
M.9 - 10 cm	9.3 a	8.8 ab	17.0 a	26.1 a	18.0 ab	26.4 a
M.9 - 15 cm	8.0 a	9.1 ab	13.5 ab	27.2 a	15.9 b	27.1 a
Rootstock (A)						
M.7	8.6 a ^y	8.1 b	11.9 a	20.2 b	21.1 a	24.2 a
M.9	8.6 a	9.2 a	14.7 a	25.2 a	18.0 b	26.2 a
Exposed length of rootstock (B)						
5 cm	8.2 a ^z	8.9 a	12.9 a	20.1 b	20.3 a	24.5 a
10 cm	8.5 a	8.3 a	13.7 a	23.6 a	19.5 a	25.0 a
15 cm	9.1 a	8.9 a	13.4 a	24.4 a	18.9 a	26.2 a
ANOVA ^x						
Rootstock (A)	NS	*	NS	***	*	NS
Exposed length (B)	NS	NS	NS	**	NS	NS
A x B	NS	NS	NS	NS	NS	NS

^z Means followed by the same letter are not significantly different using Duncan's multiple range test, $P \leq 0.05$.

^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 6. Average fruit weight according to the exposed length of rootstock in the 'Sansa' apple trees grafted on M.7 or M.9 for 6 years

Treatments	Average fruit weight (g)					
	Years after planting					
	2	3	4	5	6	7
M.7 - 5 cm	184 b ^z	145 ab	205 b	203 a	221 b	232 a
M.7 - 10 cm	181 b	138 b	206 b	218 a	228 b	233 a
M.7 - 15 cm	189 ab	156 ab	213 ab	210 a	235 ab	234 a
M.9 - 5 cm	207 a	160 ab	227 a	222 a	240 ab	230 a
M.9 - 10 cm	194 ab	157 ab	230 a	229 a	257 a	240 a
M.9 - 15 cm	200 ab	172 a	225 a	237 a	245 ab	244 a
Rootstock (A)						
M.7	185 b ^y	146 b	208 b	210 a	228 a	233 a
M.9	200 a	163 a	227 a	229 a	247 a	236 a
Exposed length of rootstock (B)						
5 cm	196 a ^z	152 a	216 a	213 a	231 a	231 a
10 cm	187 a	147 a	218 a	223 a	243 a	236 a
15 cm	194 a	164 a	219 a	223 a	240 a	239 a
ANOVA ^x						
Rootstock (A)	*	*	**	NS	NS	NS
Exposed length (B)	NS	NS	NS	NS	NS	NS
A x B	NS	NS	NS	NS	NS	NS

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^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 7. Soluble solid contents according to the exposed length of rootstock in the 'Sansa' apple trees grafted on M.7 or M.9 for 6 years

Treatments	Soluble solid contents (°Brix)					
	Years after planting					
	2	3	4	5	6	7
M.7 - 5 cm	14.8 a ^z	14.5 b	14.4 a	14.4 ab	14.5 a	14.0 a
M.7 - 10 cm	14.9 a	14.7 b	14.7 a	14.1 bc	14.4 a	14.1 a
M.7 - 15 cm	14.6 a	14.9 ab	14.9 a	13.6 c	14.5 a	14.3 a
M.9 - 5 cm	14.9 a	14.9 ab	14.7 a	15.1 a	14.3 a	15.1 a
M.9 - 10 cm	15.2 a	15.9 a	14.6 a	14.6 ab	14.7 a	14.7 a
M.9 - 15 cm	15.6 a	15.2 ab	15.0 a	14.8 a	14.7 a	14.8 a
Rootstock (A)						
M.7	14.8 a ^y	14.7 b	14.7 a	14.0 b	14.5 a	14.1 b
M.9	15.2 a	15.3 a	14.8 a	14.8 a	14.6 a	14.9 a
Exposed length of rootstock (B)						
5 cm	14.9 a ^z	14.7 a	14.6 a	14.8 a	14.4 a	14.8 a
10 cm	15.1 a	15.3 a	14.7 a	14.4 a	14.6 a	14.4 a
15 cm	15.1 a	15.1 a	15.0 a	14.2 a	14.6 a	14.6 a
ANOVA ^x						
Rootstock (A)	NS	*	NS	***	NS	*
Exposed length (B)	NS	NS	NS	NS	NS	NS
A x B	NS	NS	NS	NS	NS	NS

^z Means followed by the same letter are not significantly different using Duncan's multiple range test, $P \leq 0.05$.

^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 8. Titratable acidity according to the exposed length of rootstock in the 'Sansa' apple trees grafted on M.7 or M.9 for 6 years

Treatments	Titratable acidity (%)					
	Years after planting					
	2	3	4	5	6	7
M.7 - 5 cm	0.61 a ^z	0.64 a	0.59 a	0.63 a	0.65 ab	0.58 a
M.7 - 10 cm	0.59 ab	0.62 a	0.62 a	0.57 ab	0.67 a	0.62 a
M.7 - 15 cm	0.60 ab	0.64 a	0.66 a	0.53 b	0.65 ab	0.63 a
M.9 - 5 cm	0.57 b	0.63 a	0.55 a	0.62 a	0.61 b	0.59 a
M.9 - 10 cm	0.58 ab	0.67 a	0.57 a	0.63 a	0.65 ab	0.58 a
M.9 - 15 cm	0.57 b	0.68 a	0.62 a	0.64 a	0.66 ab	0.62 a
Rootstock (A)						
M.7	0.60 a ^y	0.63 a	0.62 a	0.58 b	0.66 a	0.61 a
M.9	0.57 b	0.66 a	0.58 a	0.63 a	0.64 a	0.60 a
Exposed length of rootstock (B)						
5 cm	0.59 a ^z	0.64 a	0.57 a	0.63 a	0.63 a	0.59 a
10 cm	0.59 a	0.65 a	0.60 a	0.60 a	0.66 a	0.60 a
15 cm	0.59 a	0.66 a	0.64 a	0.59 a	0.66 a	0.63 a
ANOVA ^x						
Rootstock (A)	*	NS	NS	*	NS	NS
Exposed length (B)	NS	NS	NS	NS	NS	NS
A x B	NS	NS	NS	NS	NS	NS

^z Means followed by the same letter are not significantly different using Duncan's multiple range test, $P \leq 0.05$.

^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

M.7 - 5 cm M.7 - 10 cm 가 [27,28]가 ,
 M.9 , 2, 3, 6, 7 M.7 30% 가 , 60%
 - 5 cm 가 M.9 - 15 cm 가 [18,20,25]가
 . , (2 4)
 6 (Table 9). 가
 3
 [4], , M.7 - 15 cm M.9 - 10
 M.9 cm , 3
 2, 3 4 (2) 16%, 5% (Table
 가 [7,26], 5). , 가
 2 5-15 , 3 30- (Tables 4, 5).
 60 , 4 100-120 5 가 100
 [5]. (M.7 - 15 cm, M.9 - 5 cm, M.9 - 10
 1 (Tables 1-3), 2 cm, M.9 - 15 cm) (6)
 . (Tables 4, 5), M.7 -
 6 15 cm (5) 6
 가 , 2 10% 6
 40-54 , 3 56-60 , 4 50-74 , M.9 - 5 cm
 (Table 4). 6 16%, 9%
 (Biennial bearing , M.9 - 10 cm, M.9 - 15 cm
 index, BI)가 0.30 가 , 6 39-43%, 31-42%
 0.60 가 (Table 4). , 5 가

Table 9. Fruit red color according to the exposed length of rootstock in the 'Sansa' apple trees grafted on M.7 or M.9 for 6 years

Treatments	Fruit red color (Hunter a value)					
	Years after planting					
	2	3	4	5	6	7
M.7 - 5 cm	3.2 c ^z	5.8 c	8.0 b	4.6 c	3.5 b	3.0 b
M.7 - 10 cm	4.7 bc	8.9 abc	8.9 b	4.4 c	4.9 b	4.1 b
M.7 - 15 cm	5.2 abc	6.0 bc	12.2 a	4.9 bc	5.3 b	5.2 ab
M.9 - 5 cm	6.7 ab	10.9 ab	12.2 a	7.9 ab	8.3 ab	7.0 ab
M.9 - 10 cm	7.7 ab	11.4 a	12.5 a	7.8 ab	12.8 a	7.3 ab
M.9 - 15 cm	8.0 a	12.1 a	12.7 a	8.7 a	14.0 a	8.8 a
Rootstock (A)						
M.7	4.4 b ^y	6.9 b	9.7 b	4.6 b	4.6 b	4.1 b
M.9	7.5 a	11.5 a	12.5 a	8.1 a	11.7 a	7.7 a
Exposed length of rootstock (B)						
5 cm	5.0 a ^z	8.4 a	10.1 a	6.3 a	5.9 a	5.0 a
10 cm	6.2 a	10.2 a	10.7 a	6.1 a	8.9 a	5.7 a
15 cm	6.6 a	9.1 a	12.5 a	6.8 a	9.7 a	7.0 a
ANOVA ^x						
Rootstock (A)	**	**	**	***	***	***
Exposed length (B)	NS	NS	NS	NS	NS	NS
A x B	NS	NS	NS	NS	NS	NS

^z Means followed by the same letter are not significantly different using Duncan's multiple range test, $P \leq 0.05$.
^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.
^x NS, *, **, *** Not significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

110 M.9 - 10 cm M.9 - 15 cm , 가
 6 가 가 가
 (Tables 4, 5), 가 (190 /
 10 a) (7-9) ' /M.9 [4,5,24,26,35]
 100 , [20,23]
 가 [20] , 가
 [23,29,30], (Tables 6-8)
 M.9 M.9 - 10 cm M.9 - 15 cm
 , M.26, MM.106 (Table 3).
 M.9 , MM.106 가
 M.9 M.26, 가 (: 10-60cm)
 MM.106 M.9 가 [36], MM.
 M.9 M.9 M.26
 M.26, MM.106 가 (: 10-
 M.9 40cm) 가
 [6,7,21,28,31]. ' ' 가 [10,16,17].
 M.26 가 가
 [11], (Tables 1-3),
 M.9 7 (1 7) M.7 가 5 가
 M.9 (Table 2) (Table 5). 가 (Table 5),
 (가 , ,)
 6 (2 7) (Tables 6-9).
 가
 가 가 [6], 가
 [21], 가 [10,15-17] M.7 - 15 cm ,
 가 가 가
 가 [28] 가 M.9 - 5 cm
 가 가 (Tables 1-9) , '
 [10,16,17] , ' /M.7 15 cm , '
 ' /M.9 5 cm
 (Table 5) M.9 - 10 cm M.9 - 15 cm
 20 cm
 (Table 3) 10 a당 누적 과실 생산량 및 수량효율
 가 [6,7,21,28,31]가 10 a
 [10,16,17] [28] , 4 M.7 10 a
 . M.9 .
 M.9 5 5 cm 10 a
 M.26 MM.106 10 cm 15 cm
 M.9 가 .
 (가 , ,) M.26 2, 3 10 a
 MM.106 가 4 M.7 - 5 cm
 32-34]가 , M.7 - 10 cm 10 a M.9 -
 가 가 [7]. 10 cm . M.7 - 15 cm
 가 190 /10 a , 10 a 6 (2 7
) M.9 - 5 cm 가 . , 10 a
 가 (Table 4), 6 (2
 7) M.7 M.9
 , 가 , M.7
 (Tables 6-9). 가 4 5 , M.7
 4 5 M.7 - 15 cm 10 a
 M.7 - 10 cm M.9

5 M.9 - 10 cm 10 a 가
 M.9 - 5 cm (Table 10). (Table 4), 가 M.7 10 a
 6 (2 7) M.7 , 4 M.9 (Tables 1-3, 10), M.7
 M.9 , 2 M.9 (Table 11), ,
 5 15 cm M.7 M.9 (Tables 10, 11).
 5 cm , 6 7 가 . 가 (Tables 1-3)
 M.7 - 5 cm M.7 - 10 cm 가 (Table 10), M.9 - 10 cm M.9 - 15 cm
 6 M.9 - 15 cm 7 가 (Tables 4, 5) 5
 , M.7 - 15 cm 가 . 가 (Table 11). 15 cm가 5 cm (Table
 , M.9 가 가 (Tables 10, 11)
 5 M.9 M.9 - 15 cm M.9 가 가
 - 5 cm M.9 - 10 cm (Table 11). 가
 가 가 [10,15-17,36]
 가 가 [5-7,34], (Table 5) M.7 - 15 cm
 가 가 (Table 10), M.9 - 5 cm
 가 가 가
 가 [6,7,21]. 가 가 [21,37] 가
 , 2 가 5 가

Table 10. Accumulated yield per 10 a according to the exposed length of rootstock in the 'Sansa' apple trees grafted on M.7 or M.9 for 6 years

Treatments	Accumulated yield per 10 a (ton)					
	Years after planting					
	2	3	4	5	6	7
M.7 - 5 cm	1.5 a ^z	3.0 a	5.3 bc	8.7 c	12.6 b	17.1 c
M.7 - 10 cm	1.4 a	2.9 a	4.9 c	8.9 c	12.9 b	17.3 bc
M.7 - 15 cm	1.9 a	3.6 a	6.1 ab	10.2 b	14.3 ab	19.2 ab
M.9 - 5 cm	1.6 a	3.4 a	6.0 ab	10.2 b	14.1 ab	18.8 abc
M.9 - 10 cm	1.8 a	3.4 a	6.7 a	11.6 a	15.0 a	20.1 a
M.9 - 15 cm	1.5 a	3.2 a	5.8 abc	11.0 ab	14.0 ab	19.2 ab
Rootstock (A)						
M.7	1.6 a ^y	3.2 a	5.4 b	9.3 b	13.3 b	17.9 b
M.9	1.6 a	3.4 a	6.2 a	11.0 a	14.4 a	19.4 a
Exposed length of rootstock (B)						
5 cm	1.6 a ^z	3.2 a	5.7 a	9.5 b	13.3 a	18.0 a
10 cm	1.6 a	3.2 a	5.8 a	10.3 a	14.0 a	18.7 a
15 cm	1.7 a	3.4 a	5.9 a	10.6 a	14.2 a	19.2 a
ANOVA ^x						
Rootstock (A)	NS	NS	*	***	*	**
Exposed length (B)	NS	NS	NS	*	NS	NS
A x B	NS	NS	*	*	NS	NS

^z Means followed by the same letter are not significantly different using Duncan's multiple range test, $P \leq 0.05$.

^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 11. Yield efficiency per tree according to the exposed length of rootstock in the ‘Sansa’ apple trees grafted on M.7 or M.9 for 6 years

Treatments	Yield efficiency (kg fruit/cm ² TCA)					
	Years after planting					
	2	3	4	5	6	7
M.7 - 5 cm	0.24 b ^z	0.16 c	0.18 c	0.23 d	0.23 b	0.23 b
M.7 - 10 cm	0.24 b	0.15 c	0.16 c	0.28 d	0.24 b	0.24 b
M.7 - 15 cm	0.38 ab	0.19 bc	0.23 c	0.33 cd	0.28 ab	0.28 b
M.9 - 5 cm	0.36 ab	0.25 b	0.28 bc	0.37 bc	0.32 a	0.38 a
M.9 - 10 cm	0.46 a	0.25 b	0.37 ab	0.47 b	0.30 ab	0.42 a
M.9 - 15 cm	0.47 a	0.39 a	0.44 a	0.69 a	0.33 a	0.45 a
Rootstock (A)						
M.7	0.29 b ^y	0.17 b	0.19 b	0.28 b	0.25 b	0.25 b
M.9	0.43 a	0.30 a	0.36 a	0.51 a	0.32 a	0.42 a
Exposed length of rootstock (B)						
5 cm	0.30 b ^z	0.20 b	0.23 b	0.30 c	0.27 a	0.30 a
10 cm	0.35 ab	0.20 b	0.26 ab	0.38 b	0.27 a	0.33 a
15 cm	0.43 a	0.29 a	0.34 a	0.51 a	0.31 a	0.37 a
ANOVA ^x						
Rootstock (A)	**	***	***	***	**	***
Exposed length (B)	*	**	*	***	NS	*
A x B	NS	NS	NS	**	NS	NS

^z Means followed by the same letter are not significantly different using Duncan’s multiple range test, $P \leq 0.05$.

^y Means followed by the same letter are not significantly different using T-test, $P \leq 0.05$.

^x NS, *, **, *** Not significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

[20] 7 10 a 가 (Table 7 5 cm, 10 cm, 15 cm M.9 M.9 가 (Tables 1-3), M.9 가 (Tables 9, 11). M.9 가 (Tables 4, 5), 10 a M.7 (Tables 1-10). M.9 (Table 10), M.9 가 (Table 11) 6 M.7 M.9 가 (Tables 1-3), 36~52% 가 (가 (Tables 5-11). M.9 10 cm (M.9 - 10 cm, M.9 - 15 cm) 가 (Table 3) (Tables 4, 5), M.9 5 cm (M.9 - 5 cm) (Tables 3-5) M.7 15 cm (M.7 - 15 cm) M.9 M.9

결론

5 cm (M.9 - 5 cm) 가
 (Tables 1-11) ' ' .
 가 .
 ' ' M.9 5 cm 가
 ' ' M.7
 15 cm 가 (Tables 1-11).

Note

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