

Research Article



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주간 절단시기 및 생장조절제를 이용한 ‘후지’/M9 사과나무 수관 상단부 생장조절

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Growth Control of Upper Part in ‘Fuji’/M.9 Apple Tree Canopy by Cutting Time of Trunk and Plant Growth Regulators

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Abstract

BACKGROUND: The vigorous shoot growth in upper part of apple tree canopy leads to poor fruit quality and flower bud formation in lower part of canopy. So, this study was conducted to develop the proper control method about the shoot growth in upper part of apple tree canopy.

METHODS AND RESULTS: Trunks of ‘Fuji’/M9 apple trees were cut (back pruned) to 2.5 m in tree height on 11 February (dormant) or 12 April (full bloom). Naphthalene acetic acid (NAA) was applied at 2.0% to cut surface when trunk was pruned. Prohexadione-calcium (Pro-Ca) was sprayed at 250 mg/L above 2.0 m in tree height at 23 April (petal fall). The NAA or Pro-Ca application after trunk was pruned at dormant (TR-2 and TR-3) significantly reduced shoot growth in upper part of canopy compared with the control (tree was only pruned at dormant, TR-1), but the percent of shoots showing the secondary growth of TR-3 was higher over 2 times than that of TR-2. The reduction of shoot growth in upper part of canopy by TR-2 and TR-3 increased the fruit red color from the lower part in the

treating year and blooming of the lower part in the following year.

CONCLUSION: Applying 2.0% NAA to cut surface of pruned apple trunk at dormant was the most effective way for stabilization of the tree vigor in upper part of the canopy in a high density apple orchard.

Key words: Blooming, Fruit red color, Naphthalene acetic acid, Prohexadione-calcium, Shoot growth

서론

1996 M.9
, 2.5
m
(slender spindle) (Yoon *et al.*, 2005; Yang *et al.*, 2009).

3~4 3.0 m
(Kim *et al.*, 1998a; Yang *et al.*, 2010, 2015),

³
가 가
(Robinson *et al.*, 2006). , M.26

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2.5 m
(Yang *et al.*, 2009).

3.0~4.0 m
(Yang *et al.*, 2009; Wertheim, 2005),
(vertical axis) (super spindle)
(Robinson *et al.*, 2006; Yang *et al.*, 2015).
Hampson (1997, 2004)

가
2~3
가 가
가
1998a; Kim and Park, 2010)

가
가
가
(Kim and Park, 2010).

가
(Kim *et al.*, 1998a),
(Ko
et al., 1999),
(Kim and Park,
2010; Yim, 2015)

Paclbutrazol
(PZL), Prohexadione-calcium (Pro-Ca), ethephon
Naphthalene acetic acid (NAA) (Wetheim
and Webster, 2005).
1.0~2.0%
(Shim *et al.*, 1983)
(gibberellic acid, GA) Pro-Ca 250
mg/L 1
(Millier, 2002)가

’ /M9
) NAA
Pro-Ca

재료 및 방법

시험재료 및 처리방법

3.5×1.5 m (10 a 190) 7
’ /M9

2004 2 , 10 cm
2.0 m 3.5 m,
60 mm, 38 mm , 2004 2 1 2 11
(2.0 m)

가
가
가
(Yang *et al.*, 2010, 2015; Sagong and Yoon,
2015).
(2.0 m) 5
(TR-1, TR-2, TR-3, TR-4, TR-5) , TR-1
2004 2 11 2.5 m
, 2
가 2
TR-2 2004 2 11 TR-1
, 2.0 g NAA
thiophanate-methyl (topsin-M, Kyung
nong Corp., Korea) 가, 100 mL가
NAA 2.0% 5 mL
. NAA 13~15
10~11℃
TR-3 2004 2 11 TR-1
, 가 5~10 cm
4 23 Pro-Ca(Apogee®, BASF Corp.,
Canada) 250 mg/L 0.5 L
. Pro-Ca 10~11
15℃
TR-4 2004 2 11
TR-1
2004 4 12 2.5 m
,

| | | | | | | | |
|----------------|-------------|---|--|--------------|--------------|------------------------------|-------|
| TR-5 | TR-4 | | 1 | 1 | | 5 | |
| | | NAA 2.0% | | | 처리 1년차의 영양생장 | (trunk cross-sectional area, | |
| . NAA | | | 13~15 | | TCA) | (3) | (11) |
| 24~25 °C | | | | 5 | 2.0 m | cm ² | 2 |
| 19 | | (2004) | 가 | 80 , | | 2.0 m | |
| 30 | | | 3 | 9 (| 11 | 3.0 cm | |
| : 3 30) | | | (N-P ₂ O ₅ -K ₂ O : | | | | |
| 21-17-17) | 100 g (10 a | 19 kg) | | (10 a | | | 2 |
| | (4~10) | | 7 | 10 a (| | | 2 |
| 1 | 1) | | | , Kim | | | |
| | 25 | | 7~10 , | | | | |
| (1998a, 1998b) | | | | | 2.0~3.5 m | | 10 cm |
| 14 | 가 | | | | | | |
| 7 | 1 | 30 mm (10 a | 30) , | | | | |
| | 9 | 35 mm (10 a | 35) | | | | |
| 2 | (2005) | | TR-1 | 처리 1년차의 과신품질 | | | |
| | | | 5 | 11 | 10 | | |
| | | | 가 | 80 , 20 | | | |
| | | | 3 | 28 (: 4 , 가 | | | |
| 4) | | (N-P ₂ O ₅ -K ₂ O : 15-6-10) | | | 5 | | |
| 100 g (10 a | 19 kg) | | | | | (NR-3000, Minolta,, Japan) | |
| (4~10) | | 1 | | | | (,) | |
| | SAS 9.2 | | | | Hunter's a | . 가 | |

Table 1. Effects of cutting time of trunk and plant growth regulator application on vegetative growth of 'Fuji'/M9 apple trees in the treating year

| No. | Cutting time | Treatment ^y Plant growth regulator | Tree height (cm) | TCA increment (cm ²) | Total shoot length (cm) | No. of shoot (ea/tree) | Avg. shoot length (cm) | 2nd shoot ratio ^x (%) |
|---|--------------|--|--------------------|----------------------------------|-------------------------|------------------------|------------------------|----------------------------------|
| Upper part of canopy above 2.0 m in tree height | | | | | | | | |
| TR-1 | 11 Feb. | None | 361 a ^z | 3.0 a | 1,825 a | 40 ab | 45.6 a | 17.6 ab |
| TR-2 | 11 Feb. | NAA 2.0% | 338 a | 3.3 a | 793 b | 27 b | 29.4 b | 13.5 b |
| TR-3 | 11 Feb. | Pro-Ca 250 mg/L | 364 a | 3.2 a | 1,390 ab | 47 a | 29.6 ab | 32.1 a |
| TR-4 | 12 Apr. | None | 360 a | 4.4 a | 1,726 a | 40 ab | 44.6 ab | 29.6 ab |
| TR-5 | 12 Apr. | NAA 2.0% | 360 a | 3.7 a | 1,239 ab | 30 ab | 41.3 ab | 25.1 ab |
| Lower part of canopy below 2.0 m in tree height | | | | | | | | |
| TR-1 | 11 Feb. | None | - | - | 3,205 a ^z | 197 a | 16.3 a | - |
| TR-2 | 11 Feb. | NAA 2.0% | - | - | 3,234 a | 191 a | 16.9 a | - |
| TR-3 | 11 Feb. | Pro-Ca 250 mg/L | - | - | 3,209 a | 198 a | 16.2 a | - |
| TR-4 | 12 Apr. | None | - | - | 3,323 a | 196 a | 17.0 a | - |
| TR-5 | 12 Apr. | NAA 2.0% | - | - | 3,210 a | 194 a | 16.5 a | - |

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

^y Trunk were cut to 2.5 m in tree height on 11 February (dormant) or 12 April (full bloom). NAA pasting to cut surfaces of trunk at the each cutting time. Pro-Ca spray above 2.0 m in tree height at petal fall (5~10 cm terminal shoot growth).

^x That was percent of shoots showing the secondary growth in the total shoots.

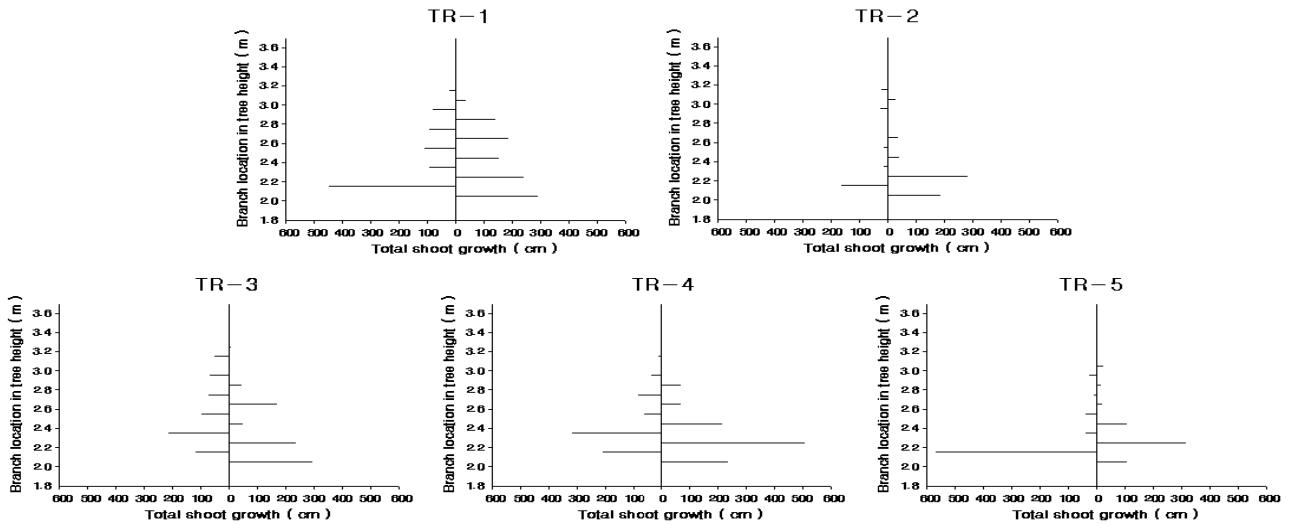


Fig. 1. Schematic illustration of shoots in upper part of canopy above 2.0 m in tree height by cutting time of trunk and plant growth regulator application of 'Fuji'/M.9 apple trees in the treating year. Total shoot growth per branch location in tree height was average value of 5 trees.

110 mm 가 2.9 m
 (Advantec, Toyo Roshi Kaisha Ltd., Japan) NAA TR-2 2.3 m
 (PR-100, Atago, Japan) Pro-Ca
 5 mL 20 mL 0.1 N NaOH TR-3 2.7 m
 pH 8.1 Kang *et al.*(2013) TR-4 NAA
 TR-5 100 cm 가 2.5 m
 처리 2년차의 전정량, 개화율, 신초생장 및 과실품질 2.1~2.3 m 500 cm TR-1
 2 (2005) 2 가 3.5 m
 가 TR-2 TR-5
 2 3 가 2.0 m
 , 4 (2.5 m)
 2 TR-1 18% 가
 TR-2 가 TR-1 56% 가
 10 11 (Fig. 2), TR-1 20 cm
 17% TR-2 TR-3
 45%, 59% , TR-1 2~3 , 40 cm
 TR-1 47%
 TR-2 TR-3 21%, 25%
 TR-1 20 cm TR-4 TR-5
 가 (Fig. 2a). 20 cm
 44%, 40% TR-1
 40 cm (Fig. 2b).
 70~75% , 4~7% 가 (IAA, NAA, IBA)
 3,205~3,323 cm, 191~198 , 16.3~17.0 cm
 가 (Table 1).
 (Fig. 1),
 TR-1 100 cm (Chae *et al.*, 2006;

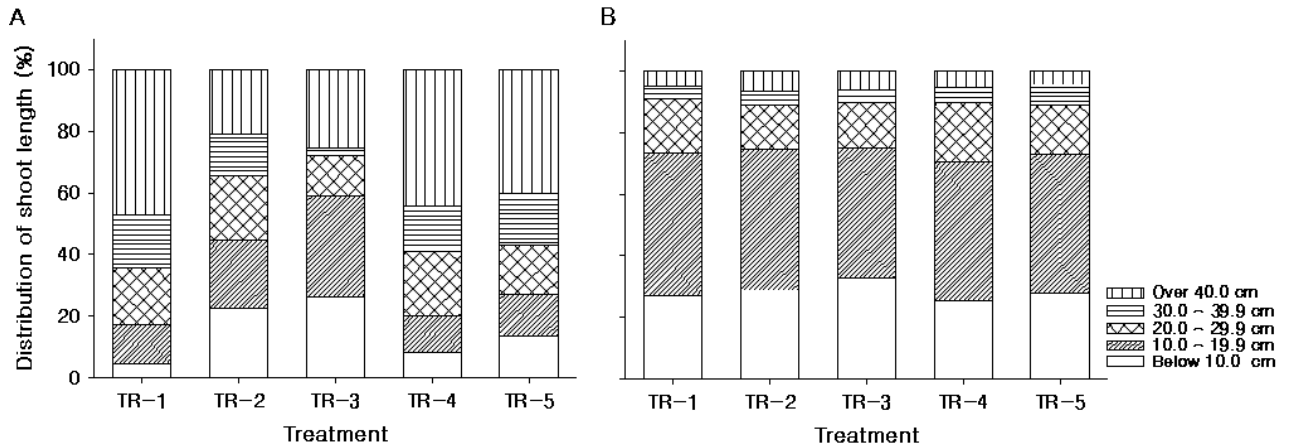


Fig. 2. Distribution of shoot length of upper part of canopy above 2,0 m (A) and lower part of canopy below 2,0 m (B) in tree height by cutting time of trunk and plant growth regulator application of 'Fuji'/M.9 apple tree in the treating year.

Byun *et al.*, 2014). IBA 0.25% mg/L
 (Yim, 2015), NAA 4
 1.0~2.0% . Pro-Ca TR-3
 가 (Miller and Ware 1980; Shim *et al.*, TR-2
 1983; Poniedzialek and Nosal, 1986) , TR-1 7 TR-3
 2 NAA 2.0% TR-2
 TR-2 (Table 1). TR-3
 57%, 33%, 37% (Table 1), 가 4 Pro-Ca
 40 cm , 4 GA₁ 가
 TR-1 (Fig. 1 and 2a). 2 (Winkler,
 Blanco Braña Jackson (1982) 1997; Basak and Rademacher, 2000; Elfving *et al.*,
 NAA NAA가 2002; Medjdoub *et al.*, 2004; Yoon and Sagong, 2005;
 30 cm 가 Sagong *et al.*, 2014) TR-3
 . NAA TR-2 TR-5 2 20 cm
 2.0~2.5 m 가 (Table 1, Fig. 2a) ,
 TR-1 TR-4 Pro-Ca
 TR-2 TR-5 2.5~3.5 m Pro-Ca가
 TR-1 TR-4 (Fig. 1).
 NAA 2.5~3.5 m
 NAA 가 (Kim and Park, 2010;
 (Fig. 1) Yim, 2015). Ko (1999)
 , 가 (6)
 (Kim 가 (7) ,
et al., 1995) , TR-2 TR-5 6 ()
 2.5~3.5 m NAA 2.5 2)
 m 가
 Pro-Ca GA₂₀ , 2 TR-4
 GA₁ (Rademacher, 40 cm
 1995; Evans *et al.*, 1997; Schupp *et al.*, 2003), Sagong TR-1 가 (Table 1; Figs. 1 and 2a).
 (2014) 가 ' /M.9 250

Table 2. Effects of cutting time of trunk and plant growth regulator application on fruit quality of 'Fuji'/M9 apple trees in the treating year

| Treatment ^y | | | Fruit weight (g) | Soluble solid content (°Brix) | Titratable acidity (%) | Hunter's a value |
|---|--------------|------------------------|--------------------|-------------------------------|------------------------|------------------|
| No. | Cutting time | Plant growth regulator | | | | |
| Upper part of canopy above 2.0 m in tree height | | | | | | |
| TR-1 | 11 Feb. | None | 363 a ^z | 15.4 a | 0.33 a | 19.4 a |
| TR-2 | 11 Feb. | NAA 2.0% | 357 a | 15.2 a | 0.36 a | 20.7 a |
| TR-3 | 11 Feb. | Pro-Ca 250 mg/L | 362 a | 15.2 a | 0.35 a | 21.4 a |
| TR-4 | 12 Apr. | None | 354 a | 15.2 a | 0.35 a | 18.9 a |
| TR-5 | 12 Apr. | NAA 2.0% | 369 a | 14.9 a | 0.35 a | 19.2 a |
| Lower part of canopy below 2.0 m in tree height | | | | | | |
| TR-1 | 11 Feb. | None | 348 a ^z | 14.1 a | 0.31 a | 14.8 b |
| TR-2 | 11 Feb. | NAA 2.0% | 349 a | 14.4 a | 0.34 a | 16.4 a |
| TR-3 | 11 Feb. | Pro-Ca 250 mg/L | 345 a | 14.4 a | 0.32 a | 16.1 a |
| TR-4 | 12 Apr. | None | 343 a | 14.1 a | 0.32 a | 15.1 b |
| TR-5 | 12 Apr. | NAA 2.0% | 355 a | 14.0 a | 0.32 a | 14.8 b |

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

^y Trunk were cut to 2.5 m in tree height on 11 February (dormant) or 12 April (full bloom). NAA pasting to cut surfaces of trunk at the each cutting time. Pro-Ca spray above 2.0 m in tree height at petal fall (5~10 cm terminal shoot growth).

처리 1년차의 과실품질

1988; Rom, 1991) 2.5 m

354~369 g, ' /M.9 10 3.5 m

가 14.9~15.4 °Brix, 0.33~ , 7 1.8 m

0.36%, 18.9~21.4 Hunter's a , 70% (Yang *et al.*, 2009)

343~355 g, 14.0~14.4 °Brix, 0.31~0.34%, 14.8~ 70%

16.4 Hunter's a

가

TR-2 TR-3 가 16.1~16.4 Hunter's a (Table 1; Fig. 2a),

14.8~15.1 Hunter's a TR-2 TR-3

(Table 2).

가

(Callesen, 1993; Wagenmakers and Callesen, 1995; Yang *et al.*, 2009, 2015), 가

가 (Jung and Choi, 2010), and Yoon, 2015) 가 (Yang *et al.*, 2009; Sagong

(Yoon *et al.*, 2005; Sagong *et al.*, 2014). (Marini *et al.*, 2002)

TR-2 TR-3 가

(Tables

1 and 2; Fig. 2a).

가

처리 2년차의 전정량, 개화율, 신초생장 및 과실품질

TR-2, TR-3, TR-4, TR-5 (2005)

TR-1 가

30% (Corelli Grappadelli, , 2 TR-2

2003), 가 510 g , TR-1 970 g 48%

70%, 60% , 50% , TR-4 1,420 g , TR-1

가 (Barritt *et al.*, 1987; Tustin *et al.*, 46% 가 2 ,

Table 3. Effects of cutting time of trunk and plant growth regulator application on pruning weight and shoot growth of 'Fuji'/M9 apple trees in the following year

| Treatment ^y | | | Pruning weight (g/tree) | Total shoot length (cm) | No. of shoot (ea / tree) | Avg. shoot length (cm) |
|---|--------------|------------------------|-------------------------|-------------------------|--------------------------|------------------------|
| No. | Cutting time | Plant growth regulator | | | | |
| Upper part of canopy above 2.0 m in tree height | | | | | | |
| TR-1 | 11 Feb. | None | 970 abc ^z | 1,342 a | 44 a | 30.5 a |
| TR-2 | 11 Feb. | NAA 2.0% | 510 c | 1,366 a | 44 a | 31.1 a |
| TR-3 | 11 Feb. | Pro-Ca 250 mg/L | 750 bc | 1,323 a | 45 a | 29.4 a |
| TR-4 | 12 Apr. | None | 1,420 a | 1,352 a | 45 a | 30.0 a |
| TR-5 | 12 Apr. | NAA 2.0% | 1,160 ab | 1,431 a | 47 a | 30.4 a |
| Lower part of canopy below 2.0 m in tree height | | | | | | |
| TR-1 | 11 Feb. | None | - | 3,156 a ^z | 178 a | 17.7 a |
| TR-2 | 11 Feb. | NAA 2.0% | - | 3,133 a | 182 a | 17.2 a |
| TR-3 | 11 Feb. | Pro-Ca 250 mg/L | - | 3,136 a | 185 a | 16.9 a |
| TR-4 | 12 Apr. | None | - | 3,151 a | 187 a | 16.8 a |
| TR-5 | 12 Apr. | NAA 2.0% | - | 3,057 a | 184 a | 16.6 a |

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

^y Trunk were cut to 2.5 m in tree height on 11 February (dormant) or 12 April (full bloom). NAA pasting to cut surfaces of trunk at the each cutting time. Pro-Ca spray above 2.0 m in tree height at petal fall (5-10 cm terminal shoot growth).

Table 4. Effects of heading cutting time and plant growth regulator application on blooming and fruit quality of 'Fuji'/M9 apple trees in the following year

| Treatment ^y | | | Blooming (%) | Fruit weight (g) | Soluble solid content (°Brix) | Titratable acidity (%) | Hunter's a value |
|---|--------------|------------------------|---------------------|------------------|-------------------------------|------------------------|------------------|
| No. | Cutting time | Plant growth regulator | | | | | |
| Upper part of canopy above 2.0 m in tree height | | | | | | | |
| TR-1 | 11 Feb. | None | 66.0 a ^z | 412 a | 14.4 a | 0.34 a | 19.2 a |
| TR-2 | 11 Feb. | NAA 2.0% | 76.0 a | 401 a | 14.3 a | 0.35 a | 19.0 a |
| TR-3 | 11 Feb. | Pro-Ca 250 mg/L | 59.1 a | 413 a | 14.4 a | 0.35 a | 19.4 a |
| TR-4 | 12 Apr. | None | 60.7 a | 419 a | 14.2 a | 0.33 a | 19.0 a |
| TR-5 | 12 Apr. | NAA 2.0% | 61.7 a | 402 a | 14.3 a | 0.34 a | 19.1 a |
| Lower part of canopy below 2.0 m in tree height | | | | | | | |
| TR-1 | 11 Feb. | None | 48.3 b ^z | 367 a | 13.4 a | 0.31 a | 15.2 a |
| TR-2 | 11 Feb. | NAA 2.0% | 63.2 a | 364 a | 13.4 a | 0.31 a | 15.4 a |
| TR-3 | 11 Feb. | Pro-Ca 250 mg/L | 62.6 a | 369 a | 13.6 a | 0.30 a | 15.5 a |
| TR-4 | 12 Apr. | None | 52.9 ab | 377 a | 13.6 a | 0.30 a | 15.6 a |
| TR-5 | 12 Apr. | NAA 2.0% | 52.4 ab | 373 a | 13.3 a | 0.31 a | 15.3 a |

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

^y Trunk were cut to 2.5 m in tree height on 11 February (dormant) or 12 April (full bloom). NAA pasting to cut surfaces of trunk at the each cutting time. Pro-Ca spray above 2.0 m in tree height at petal fall (5-10 cm terminal shoot growth).

(Table 3).
 2
 가 TR-2 가
 76.0%가 가 , TR-3 가 59.1% 가 .
 가 62.6~63.2%
 TR-1 48.3% 가
 가 (Table 4).
 TR-2 가
 TR-3 가

가 (,) (Yang *et al.*, 2009; Petri *et al.*, 2011; Cline and Bakker, 2017). 1 가 1 가 NAA 2.0% TR-2 , 1 가 2 , ' /M.9 가 NAA 2.0% , 가 5~10 cm TR-3 Pro-Ca 250 mg/L TR-2 , 1 TR-3 가 TR-2 (Tables 1 and 3; Fig. 2a). TR-3, TR-4, TR-5 1 2 1 2 가 TR-2 (Table 1), 2 가 (Yoon *et al.*, 2005), Corelli Grappadelli (2003) 50% , Greene (1996) 60% (spur flowering) 80% (Table 3) 1 가 (Table 1; Fig. 2a), TR-2 TR-3 2 (Table 4). 가 , 1 TR-1 TR-3, TR-4, TR-5 2 (Tables 1, 3, and 4; Fig. 2a). 가 (Greene, 1996), 1 6 6 (Yoon *et al.*, 2005; Yoon and Sagong, 2005), 7 (Yim, 2015) , TR-3, TR-4, TR-5 2 TR-1 (Table 4) TR-3, TR-4, TR-5 1 2 (Table 1).

결 론

TR-4 TR-5

Note

The authors declare no conflict of interest.

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