Split fertilizer application affects growth, biomass allocation, and fertilizer uptake efficiency of hybrid eucalyptus

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November 27, 2012

Vancouver WA, USA


China
International boundary
Province-level boundary
National capital
Province-level capital
Railroad
Road
RUSSIA
MONGOLIA
KAZAKSTAN
KYRGYZSTAN
XINJIANG
XIZANG
QINGHAI
GANSU
NEI MONGOL
HEILONGJIANG
JILIN
LIAONING
BEIJING
Beijing
HEBEI
SHANXI
NINGXIA
SHANDONG
SHAANXI
HENAN
JIANGSU
SHANGHAI
Shanghai
ANHUI
HUBEI
SICHUAN
ZHEJIANG
HUNAN
JIANGXI
FUJIAN
GUIZHOU
YUNNAN
GUANGXI
GUANGDONG
Guangzhou
HAINAN
TAIWAN
Taiwan
INDIA
NEPAL
BHUTAN
BANGLADESH
BURMA
LAOS
VIETNAM
Yellow Sea
East China Sea
Ulaanbaatar
P'yongyang
Seoul
Lhasa
Kathmandu
Thimphu
Hanoi
Vientiane
Ürümqi
Lanzhou
Xi'an
Chengdu
Chongqing
Wuhan
Changsha
Nanchang
Kunming
Guiyang
Nanning
Haikou
Hangzhou
Nanjing
Hefei
Zhengzhou
Jinan
Taiyuan
Shijiazhuang
Tianjin
Hohhot
Baotou
Yinchuan
Xining
Golmud
Harbin
Changchun
Shenyang
Dalian
Qingdao
Fuzhou
Xiamen
Taipei
Zhanjiang
South China Agricultural University

South China Agricultural University

- Founded in 1909
- Public
- Campus area: 550 hectares
- There are 22 colleges, including **forestry**, agriculture, horticulture, animal science, engineering, economics……

- The university has
  - 86 undergraduate programs
  - 77 masters degree programs
  - 49 doctorate programs

- **Currently, regular students : 42,000, including**
  - 38,000 undergraduates,
  - 4000 graduates
  - 69 foreign students from 18 countries

- Staff and faculty : 2,900
- The University ranks 78th among the nation's 792 universities in 2012 (http://www.gaokao.com/e/20120109/4f0a8e1773aa0.shtml).

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Background: (#1) Eucalyptus plantations develop fast in China

- Eucalyptus plantations are one of the most commercially important forest types in China.

- The earliest planting dates back to 1890 (mainly in Guangdong, Guangxi, Macao and Hong Kong).
- Earliest Eucalypt plantations were established in 1950s in Guangdong and Guangxi.
- E. Plantations area increased tremendously in 1980s.

- In 2010, E. plantation area in China reached 2,700,000 hm^2. The plantations were distributed in 600 counties (or cities) in 17 provinces, with most in Guangdong, Guangxi and Hainan (China Green Times 2010) .

Short rotation—usually 3-6 years!

Slash burning

Complete site preparation

Basal fertilizer application (200-750g per tree)

Tree planting

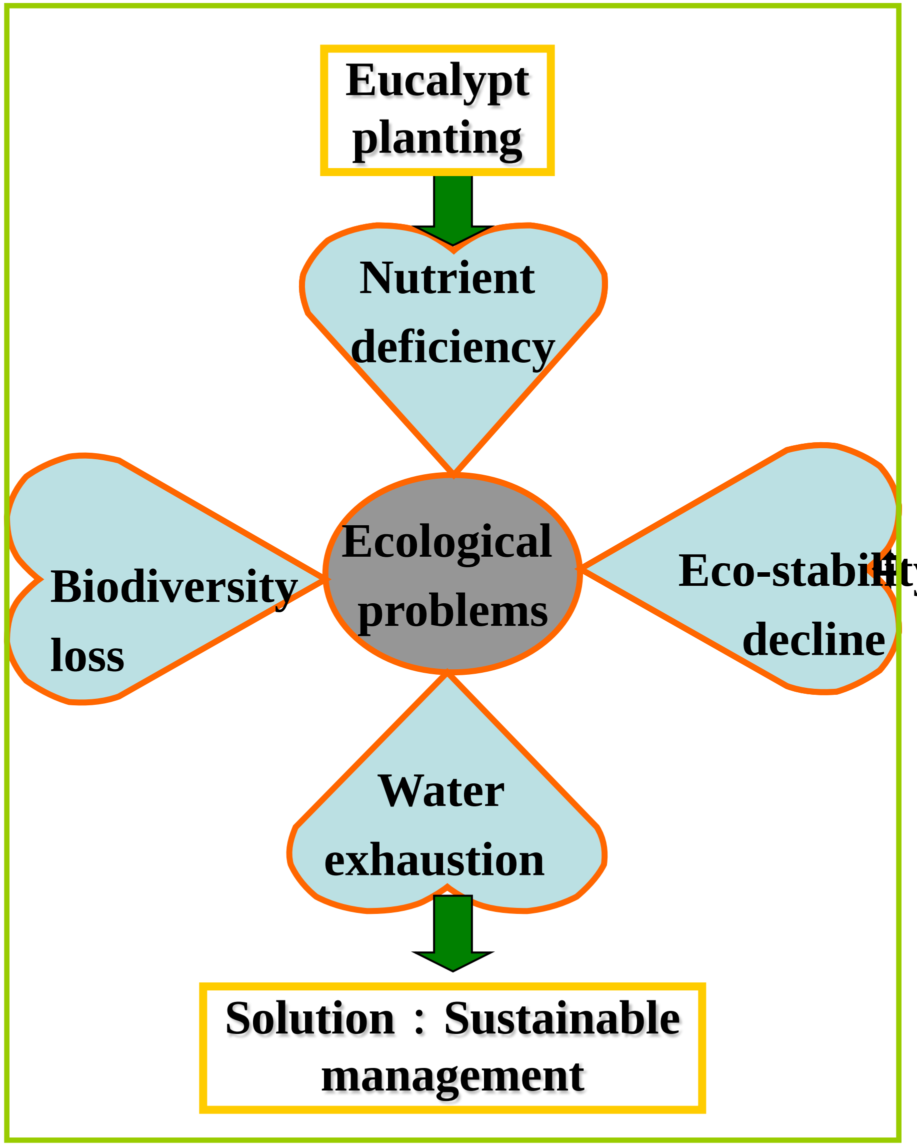
Weeding and fertilization (250-500g each year) in the first two years after establishment

Fertilization (250-500g per tree) in the third year after establishment

Clear cutting

People say “No!” to Eucalyptus plantations.

- Due to increasingly negative environmental side effects, governments and citizens in some regions have begun to restrict eucalyptus plantation development (South Rural News 2010).




Litter preservation


intercropping


Interplanting legumes


Soil tillage and fertilization

Background: (#2) Fertilization is a key measure to improve E. plantation growth

- Fertilization is a widespread silvicultural practice intended to maintain soil fertility and accelerate tree growth (Fox et al. 2007), and this is pretty true to Eucalyptus plantation management in China.
- Inappropriate fertilization practices are commonly used, leading to low fertilizer uptake efficiency and, consequently, environmental pollution.

Background: (#3) Split applications of fertilizer might improve eucalyptus tree growth and fertilizer use efficiency

- Split applications of fertilizer offer the potential to improve fertilizer use efficiency, but knowledge of the effects of this method are fairly limited (Crous et al. 2011).

- No research has reported the effects of split fertilizer application on eucalyptus tree growth and fertilizer uptake efficiency (FUE).

Purpose of this study

- We hypothesized that split applications of fertilizer would significantly improve eucalyptus tree growth and FUE, and that higher fertilization rates would not necessarily result in better growth responses.

- This study examined eucalyptus seedling growth, dry mass accumulation and allocation, nutrient uptake, and FUE under single and split applications of fertilizer at two application rates.

Materials and methods

- Experimental site:
  - South China Agricultural University (23° 15′ 87″ N, 113° 34′ 46″ E), Guangzhou, Guangdong Province, China
- Plant material:
  - The seedlings were Guanglin No. 9 clones, a hybrid of *Eucalyptus grandis* (Hill ex Maiden) × *Eucalyptus urophylla* S.T. Blake.
  - Seedlings 2 months old at the time of planting

- Potting soil:
  - Collected from the arboretum of South China Agricultural University
  - Lateritic soil developed from granite parent material
- Fertilizer:
  - granulated inorganic compound fertilizer manufactured by Dayi Agriculture Co., Ltd, China. Total N, P, and K were 15.58, 7.08, and 7.25%, respectively.

Layout of the experiment design

Treatments	Application quantities of inorganic compound fertilizer (g/seedling)			
	10 days before planting	5 months after planting	8 months after planting	Total
CK	0	0	0	0
A1	125	0	0	125
A2	62.5	62.5	0	125
A3	41.67	41.67	41.67	125
B1	250	0	0	250
B2	125	125	0	250
B3	83.33	83.33	83.33	250

Measurements and sampling

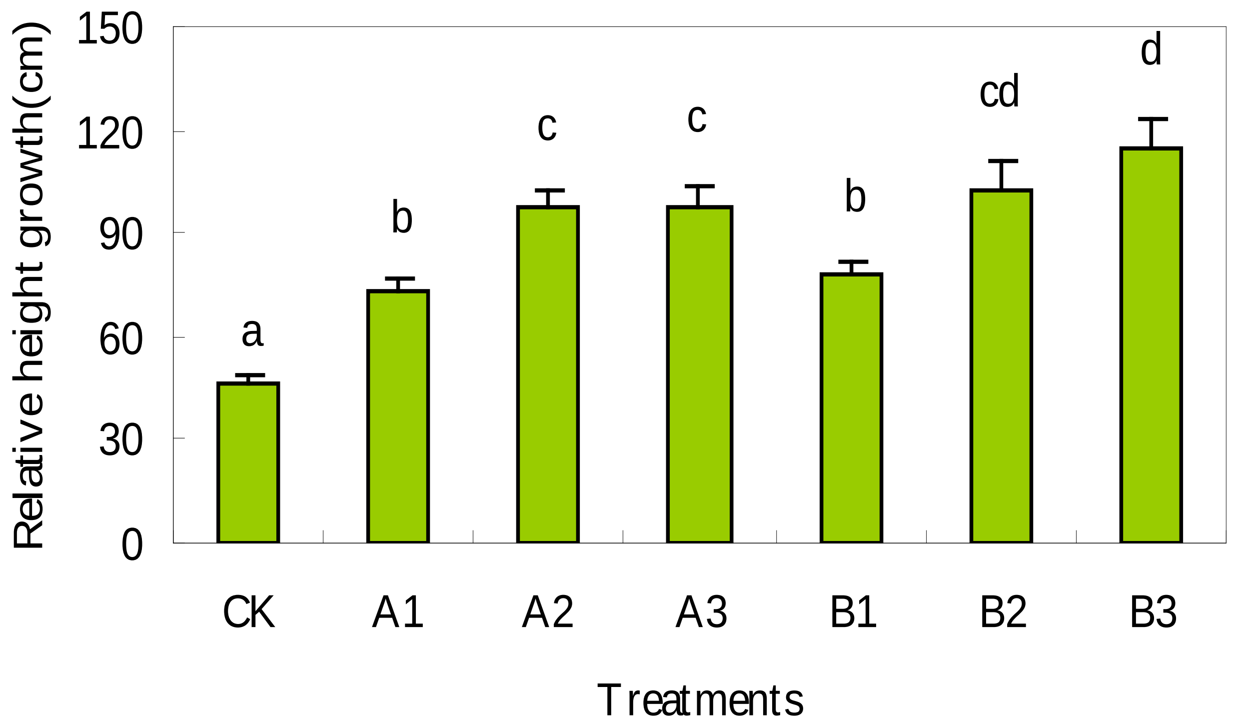
- Seedling height and root collar diameter (RCD) were measured before planting and just prior to harvest.
- On 8 Dec. 2008 seedlings were planted; on 20 Dec. 2009, all experimental trees were harvested.
- Roots, stems, branches, and leaves were separated, weighed, sampled, oven-dried, and re-weighed to determine dry mass.
- Dried samples were ground and homogenized, then stored in sealed plastic bags until analysis.
- Contents of TN, TP, and TK in roots, stems, branches, and leaves were determined (Lu 2000).

Calculations

- **Relative height growth (RHG; cm) and relative RCD growth (RRCDG; cm) of seedlings:**
  - the height and RCD at harvest relative to those at potting, respectively.
- **Nitrogen storage increments (SI):**
  - the N storage in roots, stems, branches, or leaves at harvest relative to the N storage in the respective organ of seedlings at potting.
- **Fertilizer uptake efficiency (FUE) of N, P, and K was calculated by the following formula (Erro et al. 2011):**
  - **FUE = (NUAF –NUAU) / FN × 100**, Where:
    - NUAF = the nutrient (N, P, or K) uptake amount of the fertilized seedling;
    - NUAU = the nutrient (N, P, or K) uptake amount by the unfertilized seedling (CK); and
    - FN = total fertilizer nutrient (N, P, or K) applied in the fertilization treatment

Results: (#1) Seedling growth

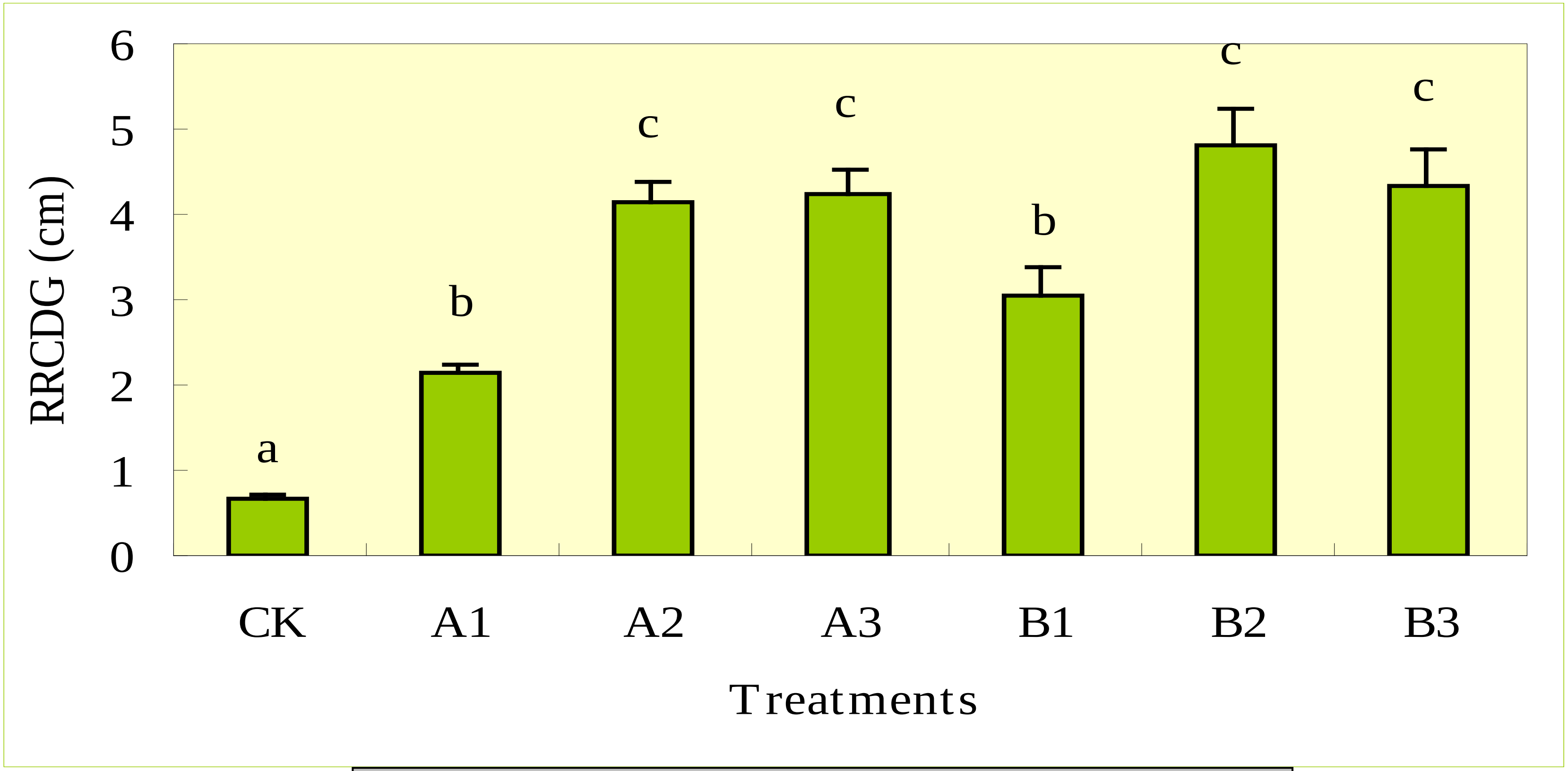
- Seedling height growth responded positively to both split application and fertilizer rates .
- B3 had significantly higher RHG than all other treatments except B2; B2 had significantly higher RHG than CK, A1, and B1. Height increments of A3 and A2 were not significantly different, nor were those of A1 and B1.
- Compared to CK, all fertilized seedlings had significantly higher RHG.



Relative height growth of different treatments

Treat ments code	Number of applicati ons	Total fertiliza tion rate
CK	0	0
A1	1	125
A2	2	125
A3	3	125
B1	1	250
B2	2	250
B3	3	250

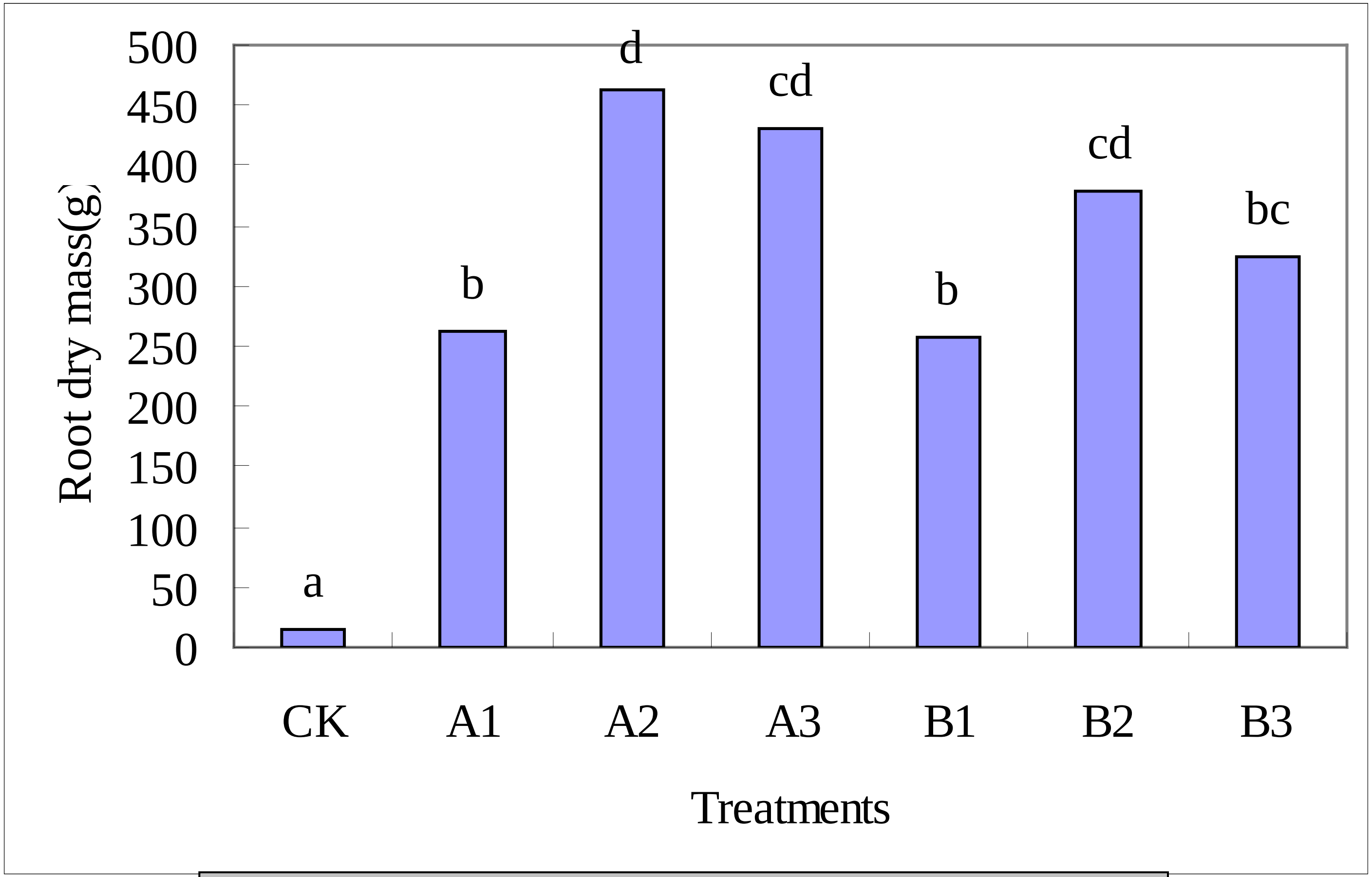
- Splitting of fertilizer application increased relative RCD growth.
- The higher fertilizer application rate did not lead to increased relative RCD growth given the same split fertilization times.
- All fertilized seedlings had significantly larger RRCDG than CK.



Relative RCD growth of different treatments

Results: (#2) Seedling biomass allocation

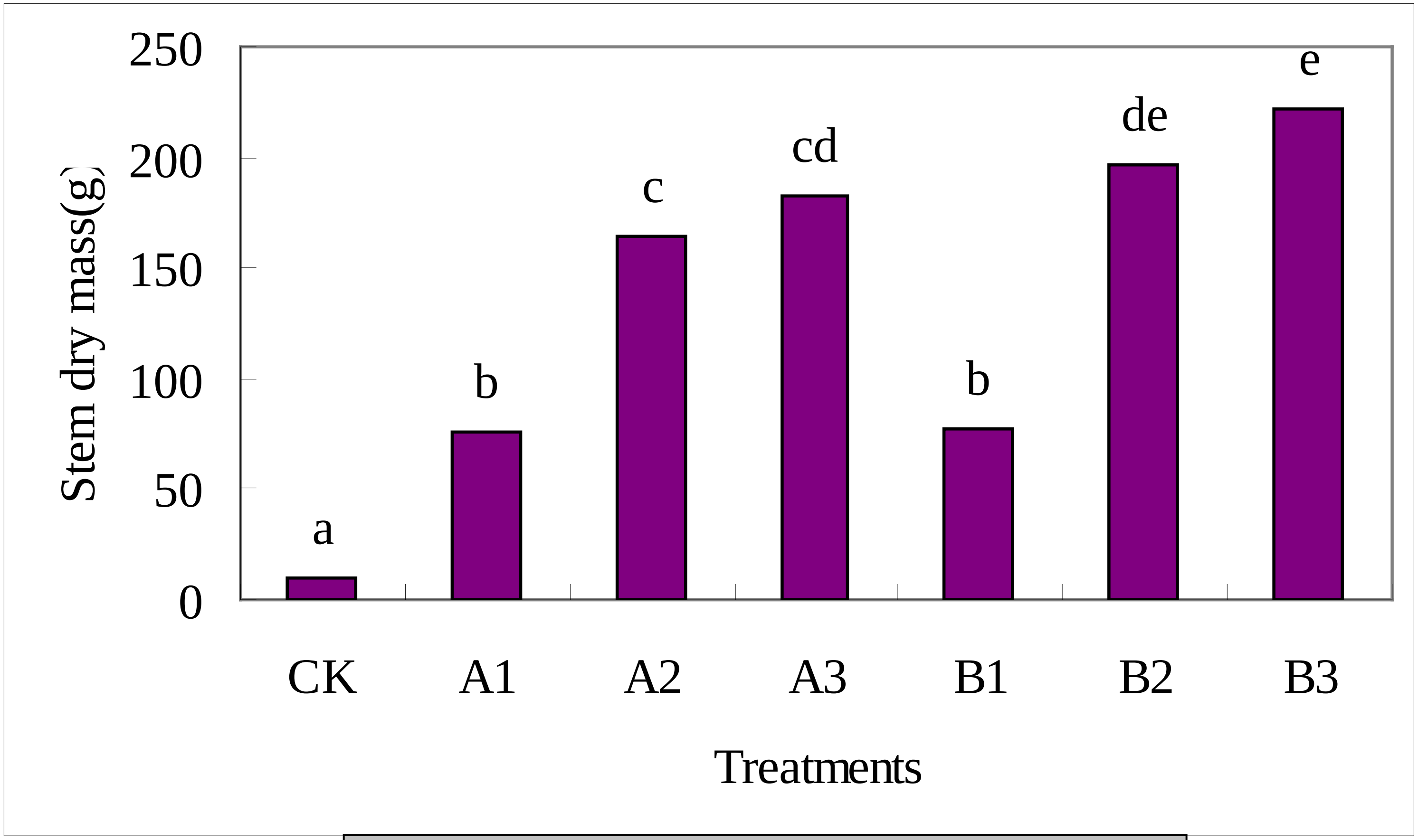
- Root mass of A2 was significantly higher than the other treatments except A3 and B2. A1 had significantly lower root mass than A2 and A3; B1 had significantly lower and relatively lower root mass than B2 and B3, respectively.



Relative RCD growth of different treatments

- Fertilizer rate did not produce significant differences in root mass.
- Fertilized seedlings had significantly higher root mass than CK.

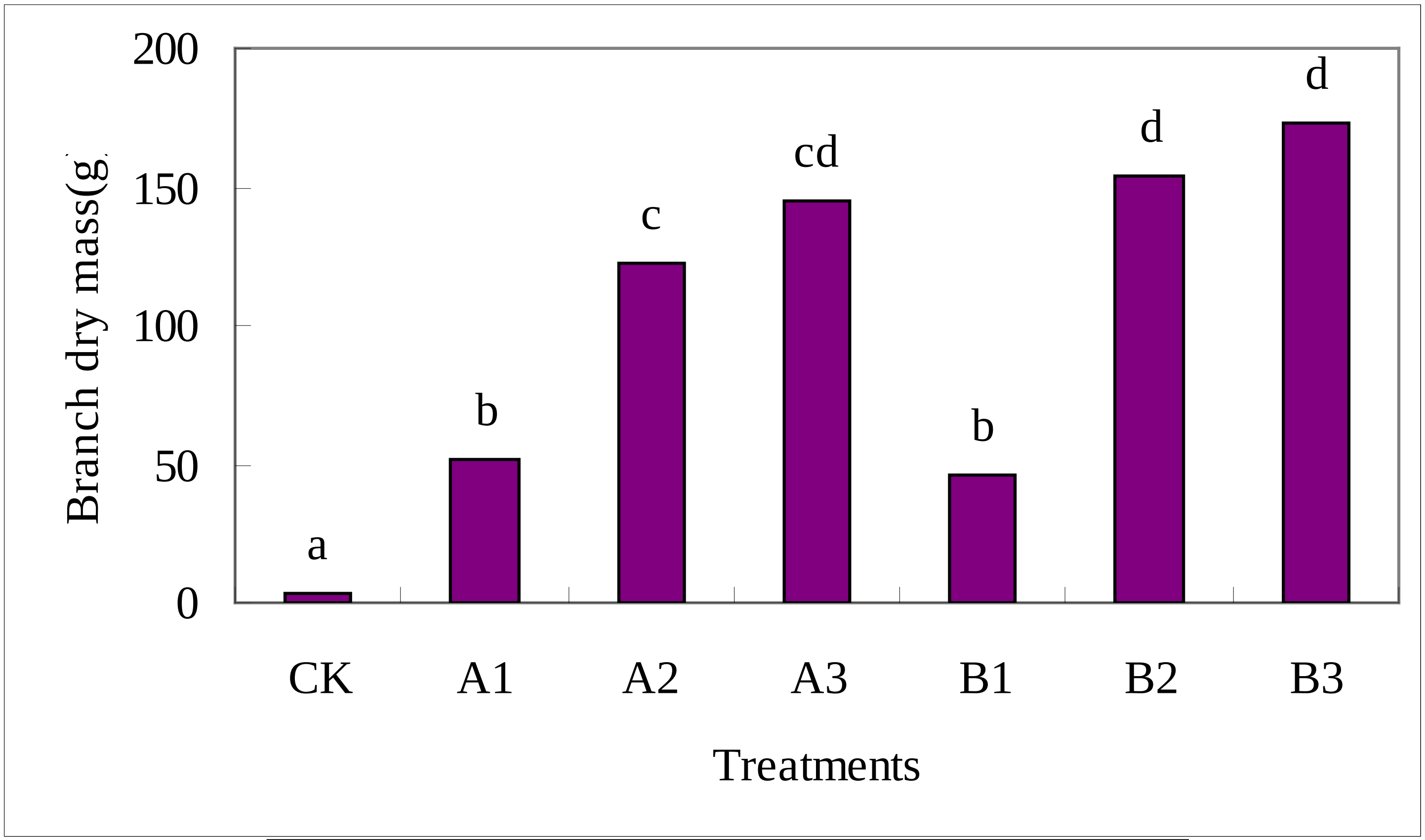
- Stem dry mass increased with split applications at both fertilization rates.
- The higher fertilization rate yielded significantly higher stem mass among split fertilization treatments.



Stem dry masses of different treatments

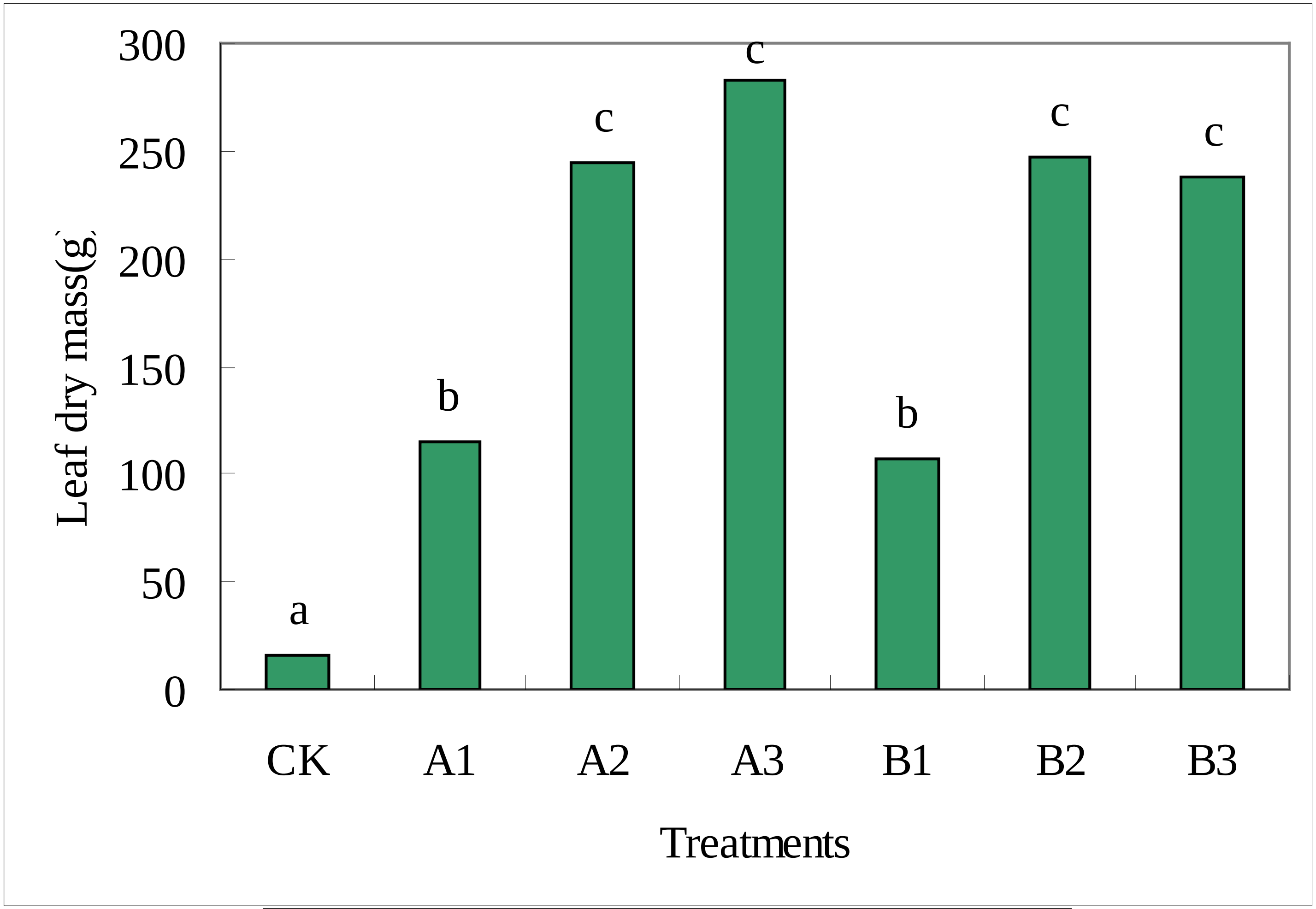
- Within a given fertilization rate, stem mass did not differ between split applications.

- Branch dry mass increased with split fertilization.
- Within a given fertilization rate, branch mass did not differ between split applications.
- Fertilization rate resulted in significant differences only when the fertilizer was applied two times(A2 and B2) .



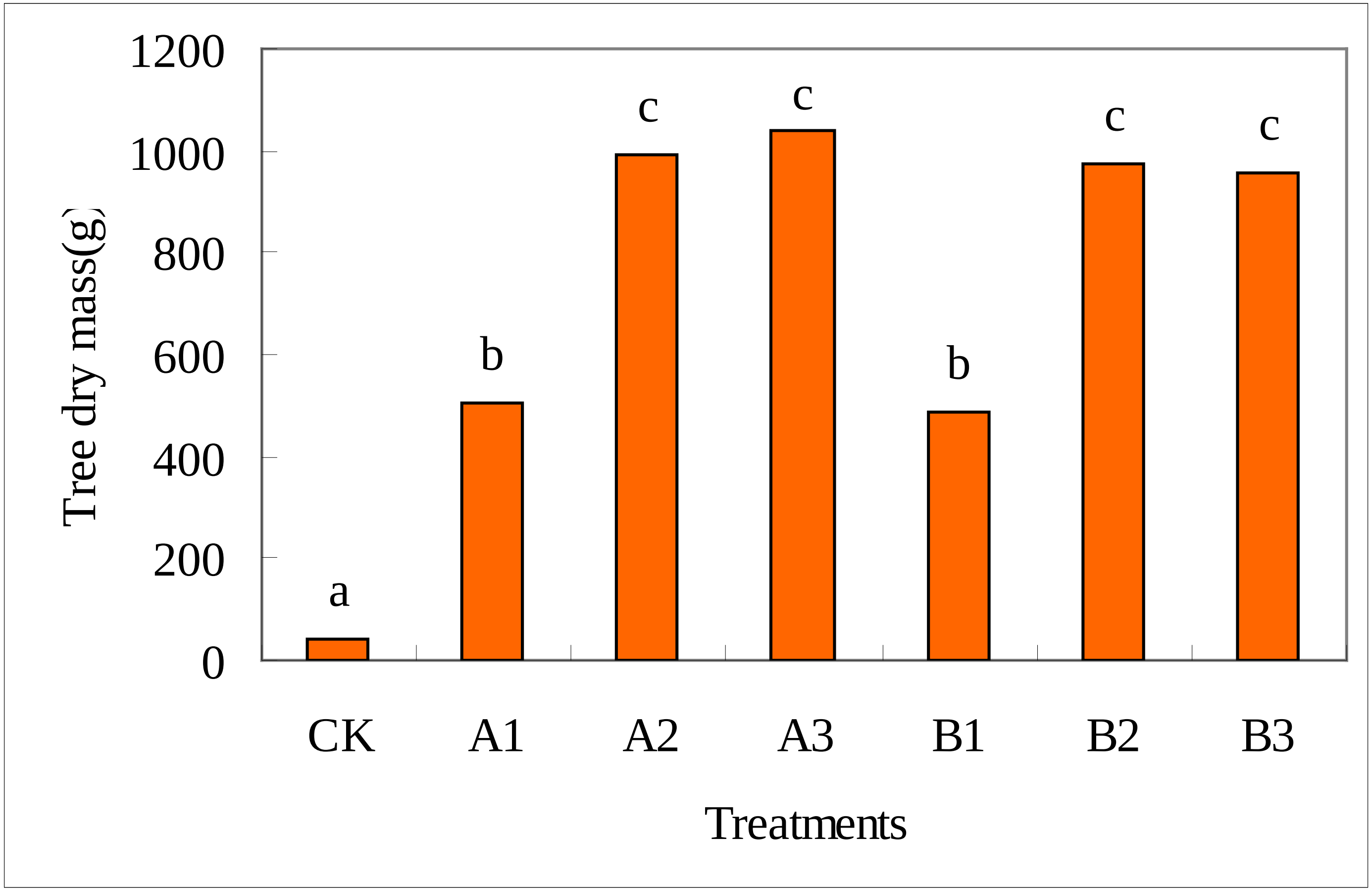
Branch dry masses of different treatments

- Leaf dry mass increased with splitting of fertilizer applications, but did not respond to increasing fertilizer rates.
- Fertilized seedlings had significantly higher leaf dry mass than CK.



Leaf dry masses of different treatments

- Split fertilizer applications resulted in seedling dry mass almost twice as high as single applications in most cases, but the number of split applications did not lead to significant differences.



Whole tree dry masses of different treatments

- Fertilization rate generally produced no differences in seedling dry mass given the same split application method.
- Fertilized seedlings had substantially higher dry masses than unfertilized seedlings.

Results: (#3) Nitrogen storage increment and allocation

- Nitrogen storage increment (SI) in roots of A2, A3, B2, and B3 were not different, but were all significantly higher than A1 and B1.
- With respect to stems, B3 had the highest nitrogen SI, and B2 had significantly higher nitrogen SI than all other treatments except B3.
- Nitrogen SI in branches was largely comparable to that observed in stems.

N storage increments (g/seedling)

Treatments	CK	A1	A2	A3	B1	B2	B3
Roots	0.025a	0.670b	2.041c	2.452c	0.805b	2.607c	2.654c
Stem	0.018a	0.139b	0.703c	0.845c	0.165b	1.140d	1.399e
Branches	0.010a	0.116b	0.429c	0.747d	0.088b	0.577cd	1.245e
Leaves	0.089a	0.574b	1.650c	2.361de	0.560b	2.203d	2.805e
Seedling	0.143a	1.499b	4.822c	6.405d	1.619b	6.765d	8.103e

- In leaves, A3 and B3 had the highest nitrogen SI and A1 and B1 had the lowest among the fertilized seedlings.
- Compared to CK, all fertilized seedlings showed significantly higher nitrogen SI in all organs.
- Split application of fertilizer significantly increased nitrogen SI of seedlings, with those of the A3 and B3 treatments being 430% and 500% higher than A1 and B1, respectively.
- Nitrogen SI of seedlings also significantly increased with fertilization rates in cases of split application.

N storage increments (g/seedling)

Treatments	CK	A1	A2	A3	B1	B2	B3
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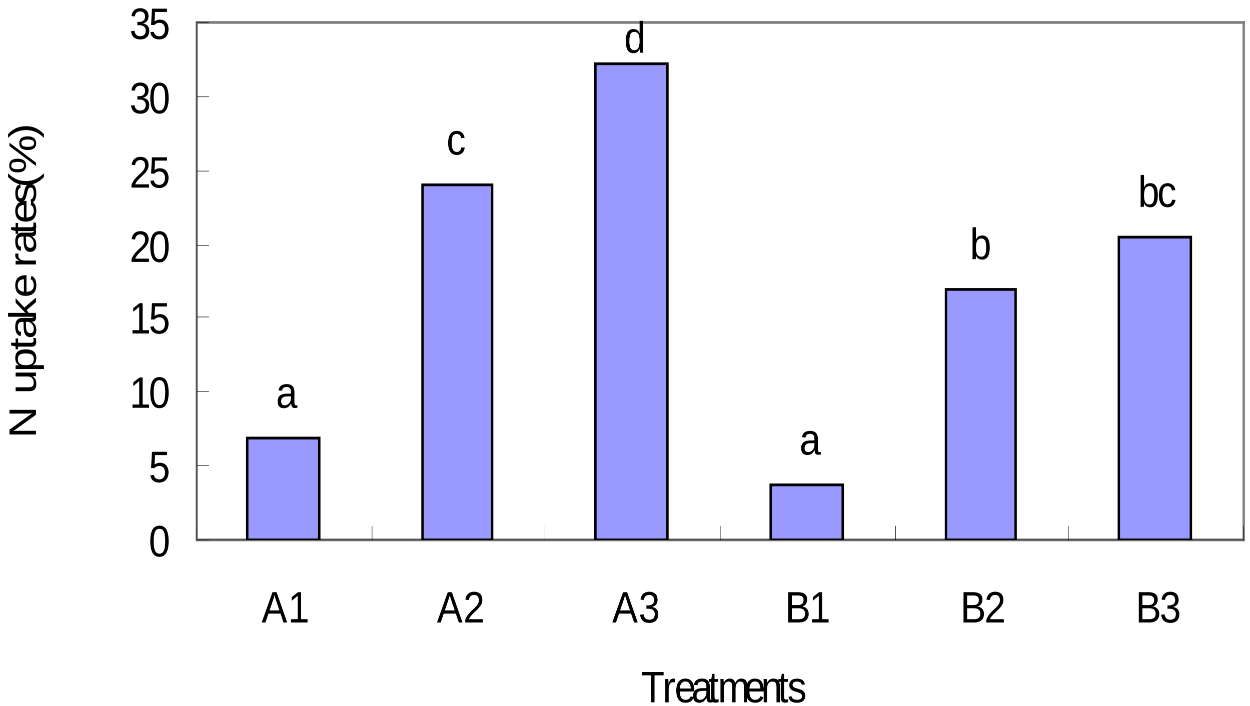
Seedling	0.143a	1.499b	4.822c	6.405d	1.619b	6.765d	8.103e

Results: (#4) Fertilizer nutrient uptake efficiency

- Fertilizer N uptake efficiency (FNUE) increased significantly with split application of fertilizer compared to single applications. The FNUE of A2 was 245% greater than that of A1, and the A3 treatment resulted in an FNUE 34% and 362% higher than A2 and A1, respectively.

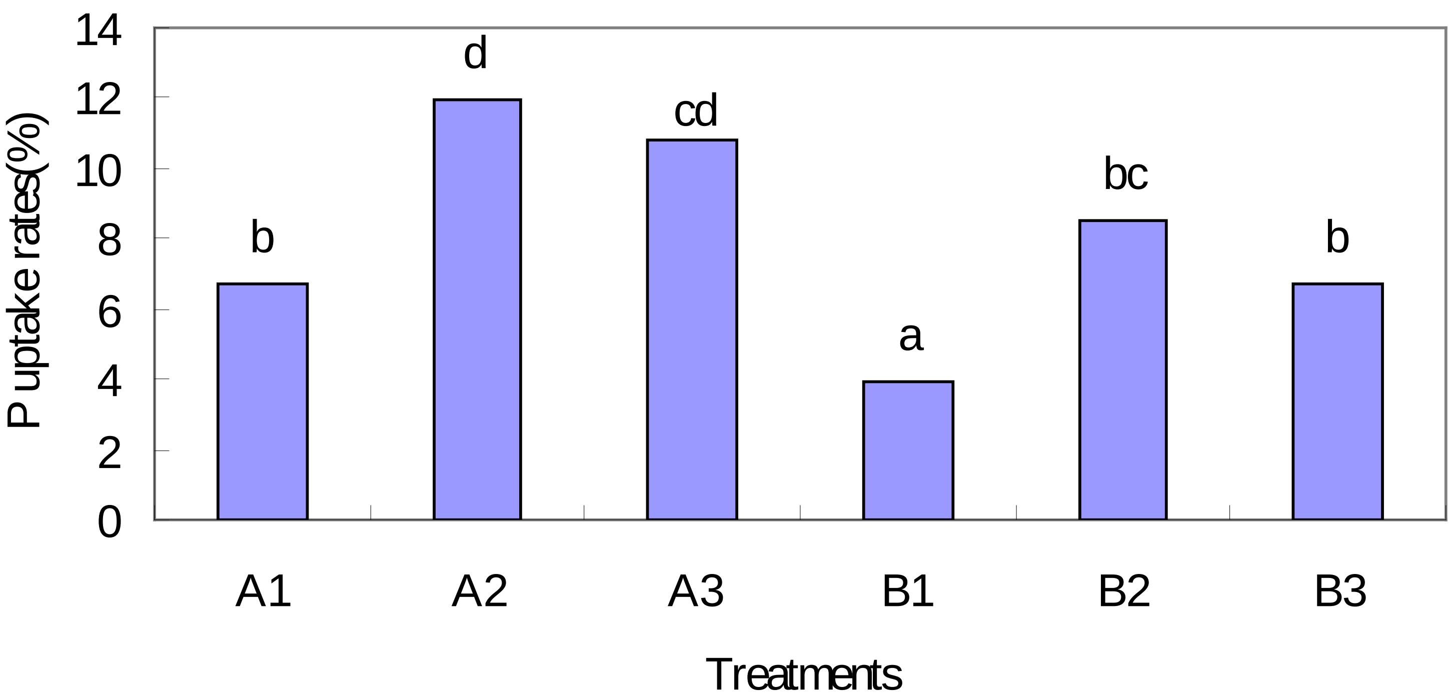
- Similarly, FNUE of B2 was 348% higher than B1, and FNUE of B3 was 20% and 439% higher than B2 and B1, respectively.



Fertilizer N uptake rates (%)

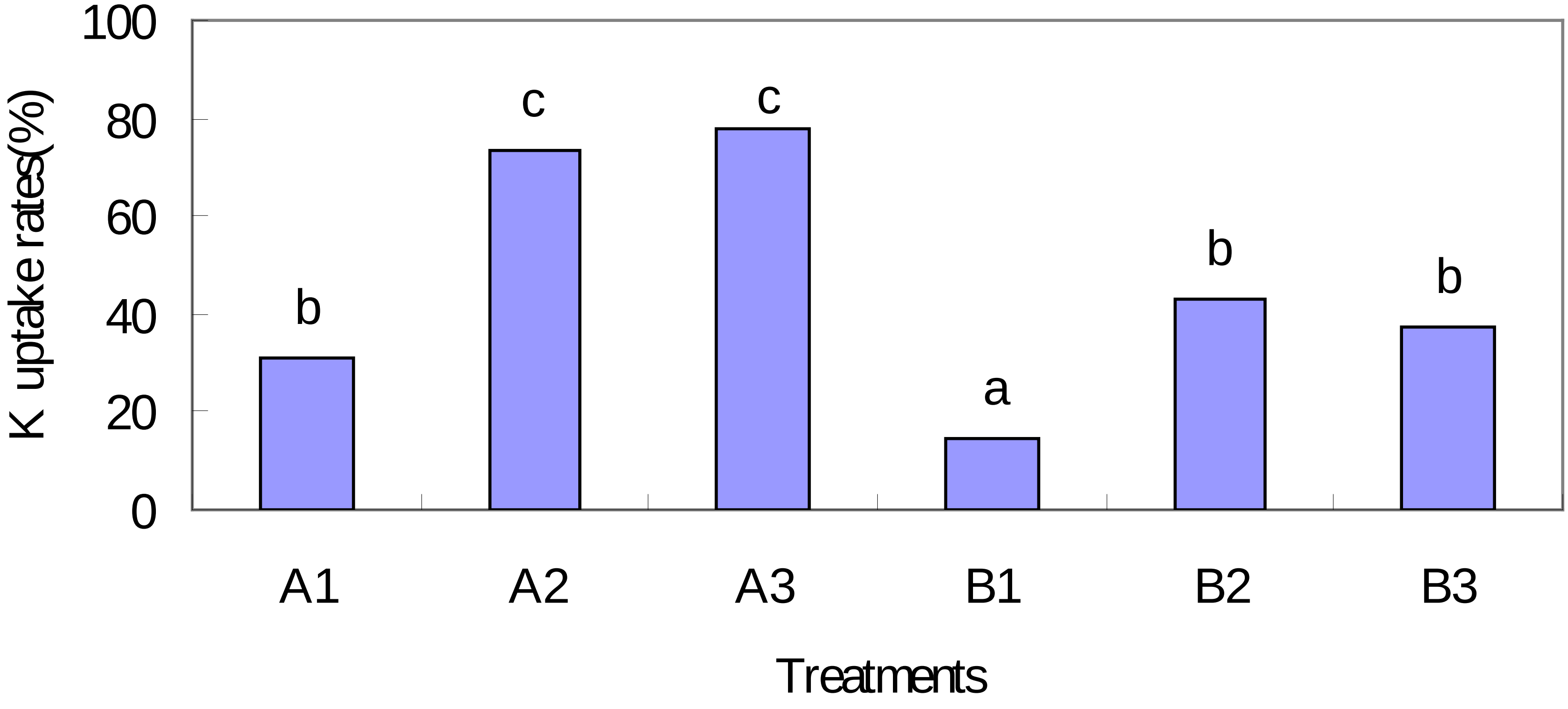
- In contrast, FNUE decreased with increasing fertilizer application rates. FNUE of the 125 g ICF/tree treatments was 78%, 41%, and 57% higher than those of the 250 g ICF/tree treatments when fertilizer was applied in one, two, or three applications, respectively.

- Split application resulted in significantly higher Fertilizer P uptake efficiency (FPUE) than single applications within a given fertilizer rate.
- Of all the treatments, A2 had the highest and B1 had the lowest FPUE.
- Like Fertilizer N uptake efficiency, FPUE dropped significantly with increasing fertilizer rates.



Fertilizer P uptake rates (%)

- Split applications resulted in significantly higher fertilizer K uptake efficiency (FKUE) compared to single applications.
- The number of split applications showed little influence on FKUE.
- As was the case for the other nutrients examined, higher fertilization rates led to significantly lower FKUE.



Fertilizer K uptake rates (%)

Conclusions

- Split applications of inorganic compound fertilizer significantly enhanced height growth, RCD growth, and dry mass of eucalyptus seedlings compared to single applications, and played a more important role than fertilization rate in seedling growth.

- All fertilized seedlings had much higher height growth, RCD growth, and dry mass than unfertilized seedlings.

Conclusions

- Nitrogen storage increments in seedling organs responded positively to split applications of fertilizer.
- Split applications resulted in pronounced increases in FUE, while increases in fertilization rate led to lower FUE.
- With seedling growth, fertilizer uptake efficiency, and operational application efficiency taken into account, split application of inorganic compound fertilizer at a relatively low rate at two application times seemed to be the optimal method of eucalyptus seedling fertilization examined in this study.


Thank you very much!