Distyly in *Forsythia suspensa* (Oleaceae)

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Abstract: Distyly provides precise pollen transfer without the costs that are associated with sexual interference and self-pollination. In thirty populations of distylous *Forsythia suspensa*, style-morph ratios varied from isoplethy (1.00 long-morph:1.00 short-morph, n=17 populations) to L-biased (1.14 long-morph:1.00 short-morph, n=13 populations). Under open pollination condition, there was no significant difference in fruit set between long-(9.11%±0.01%) and short-(8.93%±0.06%) styled morphs ($F_{(1,39)}=2.47$, $P=0.25$). The lower fertilizations of controlled intramorph pollinations (2.71%±0.02% in long-long and 2.58%±0.01% in short-short combinations) indicated that *F. suspensa* is intramorph-incompatible. There was no significant difference in fruit set of cross-pollination between long-short-(36.41%±0.07%) and short-long-(36.27 %±0.03 %) styled morphs combinations ($F_{(1,39)}=1.38$, $P=0.14$). The results of artificial outcrossing indicated that pollinator limitation may occur in the artificial populations of *F. suspensa* in northeast of China, this may be because that the low temperature and much windy in the early spring influence pollinators' kinds and activities.

Key words: distyly; *Forsythia suspensa*; floral trait

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Heterostyly is usually composed of a syndrome of traits including differences in style length and anther height, a suite of ancillary pollen and stigma polymorphisms (Barrett *et al.*, 2000). This sexual polymorphism has evolved independently in at least 28 animal-pollinated angiosperm families (Webb & Lloyd, 1986; Guitián *et al.*, 1998; Han & Kim, 1999; Barrett *et al.*, 2000; Arroyo & Barrett, 2000; Pérez *et al.*, 2004; Massinga *et al.*, 2005). In heterostylous species, populations are composed of two(distyly) or three(tristyly) floral morphs (Barrett *et al.*, 2002). Most heterostylous species have strict intramorph-incompatibility system (Massinga *et al.*, 2005), or some have strong but not strict intramorph-incompatibility system (Jacquemyn *et al.*, 2002). Xue *et al.* (2000) studied that the time and space relations on the glycoprotein forming from self-incompatibility style of Shatinyu (*Citrus grandis* var. *shatinyu*). Distylous flowers differ reciprocally in stigma and anther position, the long- and short-styled morphs (hereafter L-and S-morphs) are similar in morphology to the approach and reverse herkogamous conditions (Barrett *et al.*, 2000). Distyly provides precise pollen transfer without the costs that are associated with sexual interference and self-pollination (Charlesworth D & Charlesworth B, 1979; Kohn & Barrett, 1992; Pailler *et al.*, 2002; Barrett *et al.*, 2002). The persistence of distyly depends on tight linkage of the genes affecting anther height and stigma height, and a single diallelic Mendelian locus with dominance controls distyly (Ganders, 1979).

Distyly has been reported in some species of Oleaceae, such as *Forsythia* (Darwin, 1877; Samp-

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son,1971;Han & Kim,1999),*Abeliophyllum distichum*(Kang *et al.*,2000),*Jasminum* (Verdoorn, 1963; Ornduff, 1974), and *Schrebera* (Verdoorn, 1963). Darwin (1877) reported that thrum (short-styled morph) anthers were smaller than pin (long-styled morph) anthers in *Forsythia suspensa*. The allele determining thrum form is dominant in *Forsythia* (Sampson, 1971). Flower color of short-styled flower was more yellow than long-styled flower in *Forsythia koreana* Nakai, and the flowering of short-styled flower was earlier than long-styled flower (Han & Kim,1999). However, there is no report on the style-morph (L-and S-morphs) ratios in the *F. suspense* populations, floral trait difference between two morphs, and fertilization of intramorph and intermorph pollination. The purposes of the present contribution are to supply some of the missing information on style-morph ratios and floral traits of *F. suspensa* in the population of *F. suspense* in Northeast China, investigating fruit set under open pollination condition, and examining the consequences of intramorph-pollination between intramorph and cross-pollination between intermorph. This data may provide scientific basic for further understanding the distyly of *F. suspensa*.

1 Materials and Methods

Forsythia suspensa, a perennially deciduous shrub, is native to the north and central of China. It is cultivated broadly in China as an ornamental. The capsule is tip and egg-shaped, the number of ventricles is two, with 4—10 ovules in every ventricle. *Forsythia suspensa* flowers during spring (from March to May), and each flower lasts 5—15 days. Two stamens with equal height (occasionally appears three stamens) attaches to the base of the flower tube fused by the base of quatrefoil corolla. Style with the bilobed stigma is united.

We conducted an extensive survey to measure the relative frequencies of the two style morphs in thirty populations of *F. suspensa* (over 400 individuals per population) growing in Dalian City of Liaoning Province of China in 2005, and 20 populations (over 500 individuals per population) in Xinyang City of Henan Province of China in 2006. In the Paotai population, the following treatments were carried out: (1) 50 flowers of each of morphs were selected from 50 different individuals to measure seven floral traits, including flower length and width, petal lobe width and length, corolla tube length, stigma and anther heights; (2) Fruit sets of each of two styled morphs were investigated (n =50 individuals per morph, and 100 flowers per individual were selected, tagged and harvested after 60 days); (3) Artificial pollination treatments were designed: one is intramorph-pollination, including L-L (pollen from the other flowers of the same individual, n =20 individuals) and S-S (pollen from the other flowers of the same individual, n=20 individuals) combinations; another is cross-pollination, including L-S (pollen from the S-morph flowers) (n=20 individuals) and S-L (pollen from the L-morph flowers) (n=20 individuals) combinations. Emasculation was done before the flowers fully open; then the treated flowers were bagged using nylon bags. Hand-pollination was conducted 6-7 days after the flowers fully open. In each treatment, 100 flowers per individual were selected, tagged, treated, and harvested after 60 days.

2 Results

The flowers of *F. suspensa* have four yellow petals, each anther has two anther-petals, and each anther-petal has two clinandriums. Dehiscent mode of clinandrium is longitudinal dehiscence. Dehiscent orientation of anther is toward to petals, which may avoid pollen dispersing its own stigma to prevent self-pollination. L-morph flowers are protogyny, and S-morph flowers are protandry.

All fifty populations of *F. suspensa* sampled are dimorphic for style length. In Dalian City, style-morph ratios varied from isoplethy (1.00 L:1.00 S) (n=17 populations) to L-biased (1.14 L:1.00 S) (n=13 populations); and in Xinyang City, style-morph ratio was 1.00 L:1.00 S. In the L-morph (Fig. 1:A), stigma height was 6.12±0.05 mm (n=50), with the anther

height of 2.35±0.04 mm (n=50)(Fig. 2); whereas anther height in the S-morph (Fig. 1:B) was 6.02±0.06 mm (n=50), with the stigma height of 2.23±0.04 mm (n=50)(Fig. 2). The S-morph flower significantly exceeded the L-morph flower in size of most corolla dimensions, including flower length (S/L=1.34) and width (S/L=1.25), petal lobe width (S/L=1.17) and length (S/L=1.11), and corolla tube

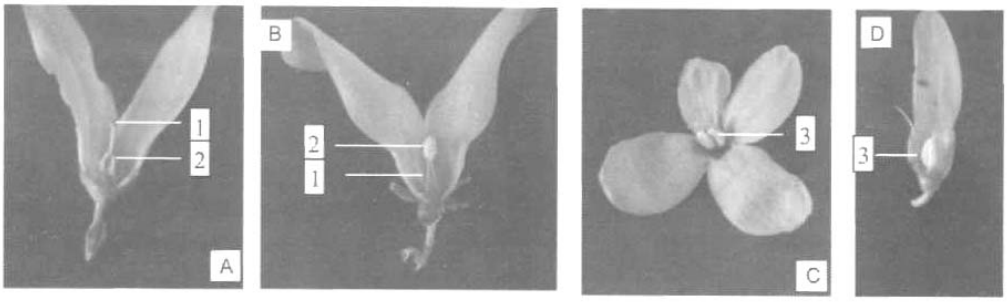

Fig. 1　Distyly in *Forsythia suspensa*

A, long-styled morph; **B**, short-styled morph; **C**, short-styled morph with inflated anthers; **D**, long-styled morph with inflated anthers; **1**, stigma; **2**, anther; **3**, inflated anthers

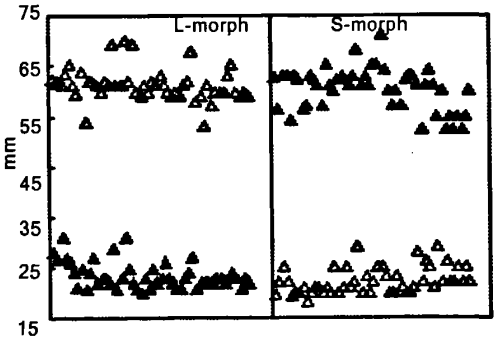

Fig. 2　The range of variation in stigma(△)and anther (▲)heights in the long- and short-styled morphs among individuals from the Paotai population growing in the northeast of China

length (S/L=1.08). Under open pollination condition, fruit set of L-morph was 9.11%±0.01% (n=50), ranging from 2.33% to 11.24 %, while showed 8.93%±0.06% (n=50), ranging from 1.90% to 11.69% in the S-morph. There is no significant difference in fruit set between two floral morphs ($F_{(1,39)}=2.47$, $P=0.25$). Controlled pollination treatments indicated that fruit sets in the L-L and S-S combinations are 2.71%±0.02% (n=20) and 2.58%±0.01% (n=20), respectively; while showed 36.41% ±0.07% (n=20) and 36.27%±0.03% (n=20) in the L-S and S-L combinations, respectively, and there was no significant difference in fruit sets between the L-S and S-L combinations ($F_{(1,39)}=1.38$, $P=0.14$).

3　Discussion

Forsythia suspensa exhibits the typical floral morphological syndrome of distylous species, the L-morph flower has a relatively high stigma and low anthers, while the S-morph flower has high anthers and a low stigma. The floral trait differences between the S- and L-morphs in the *F. suspensa* is in agreement with what has been observed in the other distylous species (Ganders, 1979; Riveros *et al.*, 1995; Li & Johnston, 2001).

The lower fruit set under open pollination in the natural populations may be from the lack of pollen availability and viability, pollinator activity, and ecological and physiological factors related to pollination mechanism (Kang *et al.*, 2000). Pollinators visit flowers to collect pollen or nectar, at the same time playing an important role as pollen-vectors, and they influence fruit set rates. The fruit set of artificial cross-pollination (36.34% of the average of the L-S and S-L combinations) in *F. suspensa* is greater than that of open pollination (9.02%), which indicates that pollinator limitation

potentially occurs in the Paotai population. In the Paotai population of *F. suspensa*, pollination appears to be affected primarily by climate factors during the blooming time, such as temperature and wind. If climate conditions are windy and cloudy with low temperature, large size pollinators' activities reduce and their visitation rate are also low. During over 5 days observations, only four species of insects are founded near or on *F. suspensa*, including two species of bee, one species of beetle, and one species of spider.

Heterostyly has evolved to prevent self-pollination and entrust pollination between individuals of different types, and there is an effective incompatibility system in the distylous species (Barret *et al.*, 2000). Ornduff (1966) suggested that heterostylous species are intramorph-incompatible originally, but the dioecous evolution may be from the selection to promote outcrossing because of the breakdown of incompatibility. The occurrence of unusual incompatibility systems in distylous Villarsia (Ornduff, 1988) and tristylous Narcissus (Sage *et al.*, 1999) indicate that the morphological components of heterostyly are not always associated with intramorph mating barriers typical of species with diallelic incompatibility (Barrett *et al.*, 2000). Indeed, as more heterostylous species are studied experimentally it is evident that many are self-compatible (Barrett *et al.*, 2000). The lower intramorph fertilization of controlled intramorph pollinations in *F. suspensa* indicated that this species is intramorph-incompatible, and the result is similar with the result by Ryu *et al.* (1976) on heterostyly-incompatibility of *A. distichum* (1.3% fruit set).

Kohn & Barrett(1992) reported that in the heterostylous species, individuals of long-styled morph act as female and short-styled type as male. The fruit set of the S-morph flower in the distylous Sarcotheca celebica is lower than that of the L-morph flower (Lack & Kevan, 1987). In some flowers of *F. suspensa*, anthers of L-(Fig. 1:D) and S(Fig. 1:C)-morphs both appear inflated and persistently un-dehiscent during the flowering, but the frequency of flowers with inflated anther in S-morph (2.84%±0.01%, n=1000) is more than that of L-morph (0.12%±0.01%, n=100 0) in the Paotai population ($U=0.000, W=237, P<0.01$). This phenomenon may be relation with the natural conditions of the Paotain population, but it is necessary to further study the evolution and adaptive significance of inflated anther occurring in *F. suspensa*.

References:

Arroyo J, Barrett S C H. 2000. Discovery of distyly in *Narcissus* (Amaryllidaceae)[J]. *Am J Bot*, **87**: 748-751

Barrett S C H. 2002. The evolution of plant sexual diversity[J]. *Nat Rev Genet*, **3**: 274-284

Barrett S C H, Jesson L K, Baker A M. 2000. The evolution and function of stylar polymorphisms in flowering plants[J]. *Ann Bot*, **85**(Suppl A): 253-265

Barrett S C H, Wilken D H, Cole W W. 2000. Heterostyly in the Lamiaceae: the case of *Salvia brandegeei*[J]. *Plant Syst Evol*, **223**: 221-229

Charlesworth D, Charlesworth B. 1979. A model for the evolution of distyly[J]. *Am Nat*, **114**: 467-498

Darwin C. 1877. The different forms of flowers on plants of the same species[M]. London: John Murray

Ganders F R. 1979. The biology of heterostyly[J]. *New Zeal J Bot*, **17**: 607-635

Guitián J, Guitián P, Medrano M. 1998. Floral biology of the distylous Mediterranean shrub *Jasminum fruticans* (Oleaceae)[J]. *Nord J Bot*, **18**: 195-201

Han I S, Kim J G. 1999. Characteristics of flowers and flowering between distyly in Korean golden-bells (*Forsythia koreana*)[J]. *J Korean Soc Hort Sci*, **40**: 769-771

Jacquemyn H, Brys R, Hermy M. 2002. Patch occupancy, population size and reproductive success of a rorest herb (*Primula elatior*) in a fragmented landscape[J]. *Oecologia*, **130**: 617-625

Kang U, Chang C S, Kim Y S. 2000. Genetic structure and conservation considerations of rare endemic *Abeliophyllum distichum* (Oleaceae) in Korea[J]. *J Plant Res*, **113**: 127-138

Kohn J R, Barrett S C H. 1992. Experimental studies on the functional significance of heterostyly[J]. *Evolution*, **46**: 43-55

Lack A J, Kevan P G. 1987. The reproductive biology of a distylous tree, *Sarcotheca celebica* (Oxalidaceae) in Su-Lawesi, Indonesia[J]. *Bot J Linn Soc*, **95**: 1-8

Li P, Johnston M O. 2001. Comparative floral morphometrics of distyly and homostyly in three evolutionary lineages of *Amsinckia* (Boraginaceae)[J]. *Can J Bot*, **79**: 1 332-1 348

Massinga P H, Johnson S D, Harder L D. 2005. Heteromorphic incompatibility and efficiency of pollination in two distylous *Pentanisia species* (Rubiaceae)[J]. *Ann Bot*, **95**: 389-399

Ornduff R. 1966. Origin of dioecism from heterostyly in *Nymphoides* (Menyanthaceae)[J]. *Evolution*, **20**: 309-314

Ornduff R. 1988. Distyly and monomorphism in *Villarsia* (Menyanthaceae): some evolutionary considerations[J]. *Ann Mo Bot Gard*, **75**: 761-767

Ornduff R. 1974. Heterostyly in South African flowering plants:

A conspectus[J]. *J S Afr Bot*,**40**:169－187

Pailler T, Maurice S, Thompson J D. 2002. Pollen transfer patterns in a distylous plant with overlapping pollen-size distributions[J]. *Oikos*,**99**:308－316

Pérez R, Vargas P, Arroyo J. 2004. Convergent evolution of flower polymorphism in *Narcissus* (Amaryllidaceae)[J]. *New Phytol*, **161**:235－252

Riveros G M, Barria O R, Humana P A M. 1995. Self-compatibility in distylous *Hedyotis salzmannii* (Rubiaceae)[J]. *Plant Syst Evol*,**194**:1－8

Ryu T Y, Yeam D Y, Kim Y J, *et al*. 1976. Studies on heterostyly incompatibility of *Abeliophyllum distichum*[J]. *Seoul Nat Univ Coll Agric Bull*,**1**:113－120

Sage T L, Strumas F, Cole W W, *et al*. 1999. Differential ovule development following self-and cross-pollination: The basis of self-sterility in *Narcissus triandrus* (Amaryllidaceae)[J]. *Am J Bot*,**86**:855－870

Sampson D R. 1971. Mating group ratios in distylic *Forsythia* (Oleaceae)[J]. *Can J Genet Cytol*,**13**:368－371

Verdoorn I C. 1963. Oleaceae[J]. *Flora S Afr*,**26**:100－128

Webb C J, Lloyd D G. 1986. The avoidance of interference between the presentation of pollen and stigmas in angiosperms. II. Herkogamy[J]. *New Zeal J Bot*,**24**:163－178

Xue MN(薛妙男), Li N(李楠), Zhang XH(张杏辉), *et al*. 2000. The time and space relations on the glycoprotein forming from self-incompatibility style of Shatinyu (沙田柚自交不亲和花柱糖蛋白产生的时空关系)[J]. *Guihaia*(广西植物),**20**(2):164－167

连翘的二型花柱

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摘 要：报道了连翘中的二型花柱(长花柱和短花柱)。长花柱的柱头和雄蕊高度分别为 6.12±0.05 mm 和 2.35±0.04 mm,短花柱则为 2.23±0.04 mm 和 6.02±0.06 mm。短花柱花的花冠大小明显超过长花柱。开放授粉条件下,长短花柱花的座果率分别为 9.11%±0.04%和 8.93%±0.07%。人工异交的座果率在长－短(36.8%±0.04%)与短－长(36.2%±0.07%)组合间无明显差异($F_{(1,39)}=1.38$, $P=0.14$)。人工异交实验表明,传粉者限制可能发生在生长于中国东北部的人工连翘种群中,这可能是因为该地区早春的低温和多风气候条件影响传粉者的种类和活动。

关键词：二型花柱；连翘；花性状

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需要进一步通过拟南芥 β 亚基和 γ 亚基缺失突变体细胞中提取蛋白质试验进行确证。

参考文献：

孙大业，郭艳林，马力耕，等. 2001. 细胞信号转导(第 3 版)[M]. 北京：科学出版社

汪家政，范明. 2000. 蛋白质技术手册[M]. 北京：科学出版社

Ellis B E, Miles G P. 2001. One for all[J]. *Science*,**292**:2 022－2 023

Jones A M, Assmann S M. 2004. Plants: the last model system for G-protein research [J]. *European Molecular Biology Organization*,**5**:572－578

Kashino Y. 2003. Separation methods in the analysis of protein membrane complexes [J]. *Chromatography B J*,**797**:191－216

Kato C, Mizutani T. 2004. Characterization of heterotrimeric G protein complexes in rice plasma membrane[J]. *Plant J*,**38**:320－331

Komatsu S, Yang G. 2004. Alterations by a defect in a rice G protein α subunit in probenazole and pathogen-induced responses [J]. *Plant Cell Environ*,**27**:947－953

Lehner I, Niehof M, Borlak J. 2003. An optimized method for the isolation and identification of membrane proteins[J]. *Electrophoresis*,**24**:1 795－1 808

Pandey S, Assmann S M. 2004. Arabidopsis putative G protein-coupled receptor GCR1 interacts with the G protein subunit GPA1 and regulates Abscisic Acid signaling[J]. *Plant Cell*,**16**, 1 616－1 632

Sakmar T P. 2002. Structure of rhodopsin and the superfamily of seven-helical receptors: the same and not the same[J]. *Curr Opin in Cell Biol*,**14**:189－195

Ullah H, Chen J G. 2001. Modulation of cell proliferation by heterotrimeric G protein in *Arabidopsis*[J]. *Science*,**292**:2 066－2 069

连翘的二型花柱

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参考文献(27条)

1. Arroyo J;Barrett S C H Discovery of distyly in Narcissus (Amaryllidaceae) 2000

2. Barrett S C H The evolution of plant sexual diversity 2002

3. Barrett S C H;Jesson L K;Baker A M The evolution and function of stylar polymorphisms in flowering plants 2000(Suppl A)

4. Barrett S C H;Wilken D H;Cole W W Heterostyly in the Lamiaceae:the case of Salvia brandegeei 2000

5. Charlesworth D;Charlesworth B A model for the evolution of distyly 1979

6. Darwin C The different forms of flowers on plants of the same species 1877

7. Ganders F R The biology of heterostyly 1979

8. Guitiá J;Guitiá P;Medrano M Floral biology of the distylousMediterranean shrub Jasminum fruticans (Oleaceae) 1998

9. Han I S;Kim J G Characteristics of flowers and flowering between distyly in Korean golden-bells (Forsythia koreana) 1999

10. Jacquemyn H;Brys R;Hermy M Patch occupancy,population size and reproductive success of a rorest herb (Primula elatior) in a fragmented landscape 2002

11. Kang U;Chang C S;Kim Y S Genetic structure and conservation considerations of rare endemic Abeliophyllum distichum (Oleaceae) in Korea 2000

12. Kohn J R;Barrett S C H Experimental studies on the functional significance of heterostyly 1992

13. Lack A J;Kevan P G The reproductive biology of a distylous tree,Sarcotheca celebica (Oxalidaceae) in Su-Lawesi,Indonesia 1987

14. Li P;Johnston M O Comparative floral morphometrics of distyly and homostyly in three evolutionary lineages of Amsinckia (Boraginaceae) 2001

15. Massinga P H;Johnson S D;Harder L D Heteromorphic incompatibility and efficiency of pollination in two distylous Pentanisia species (Rubiaceae) 2005

16. Ornduff R Origin of dioecism from heterostyly in Nymphoides (Menyanthaceae) 1966

17. Ornduff R Distyly and monomorphism in Villarsia(Menyanthaceae):some evolutionary considerations 1988

18. Ornduff R Heterostyly in South African flowering plants:A conspectus 1974

19. Pailler T;Maurice S;Thompson JD Pollen transfer patterns in a distylous plant with overlapping pollen-size distributions[外文期刊] 2002(2)

20. Pérez R;Vargas P;Arroyo J Convergent evolution of flower polymorphism in Narcissus (Amaryllidaceae) 2004

21. Riveros G M;Barria O R;Humana P A M Self-compatibility in distylous Hedyotis salzmannii (Rubiaceae) 1995

22. Ryu T Y;Yeam D Y;Kim Y J Studies on heterostyly incompatibility of Abeliophyllum distichum 1976

23. Sage T L;Strumas F;Cole W W Differential ovule development following self-and cross-pollination:The basis of self-sterility in Narcissus triandrus (Amaryllidaceae) 1999

24. Sampson D R Mating group ratios in distylic Forsythia (Oleaceae) 1971

25. Verdoorn I C Oleaceae 1963

26. Webb C J;Lloyd D G The avoidance of interference between the presentation of pollen and stigmas in angiosperms.Ⅱ.Herkogamy 1986

27. 薛妙男,李楠,张杏辉,杨继华 沙田柚自交不亲和花柱糖蛋白产生的时空关系[期刊论文]-广西植物 2000(2)

本文读者也读过(10条)

1. 钟智波.罗世孝.李爱民.吴小琴.张奠湘.ZHONG Zhi-bo.LUO Shi-xiao.LI Ai-min.WU Xiao-qin.ZHANG Dian-xiang 绣球茜的二型花柱及其传粉生物学初步研究[期刊论文]-热带亚热带植物学报2009,17(3)

2. 冯建菊.谭敦炎.FENG Jian-ju.TAN Dun-yan 软紫草二型花柱植株结实特性的比较研究[期刊论文]-西北植物学报2006,26(12)

3. 邓运川.张会欣 连翘栽培管理[期刊论文]-中国花卉园艺2010(8)

4. 牛风英 连翘育苗技术[期刊论文]-内蒙古林业2008(10)

5. 王少平.林紫玉.牛坚.王秋晓 GA3及Al2(SO4)3对连翘切枝催花效果的影响[期刊论文]-河南科技学院学报（自然科学版）2008,36(2)

6. 铁军.金山.茹文明.张志翔.TIE Jun.JIN Shan.RU Wen-ming.ZHANG Zhi-xiang 连翘花粉活力和柱头可授性研究[期刊论文]-山西大学学报(自然科学版)2008,31(4)

7. 陈明林.游亚丽.张小平.CHEN Ming-lin.YOU Ya-li.ZHANG Xiao-ping 花柱异型研究进展[期刊论文]-草业学报2010,19(1)

8. 刘铭.温春秀.田伟.周巧梅.谢晓亮 连翘人工辅助授粉提高座果率的研究[会议论文]-2006

9. 朱小强.王斌 施肥对连翘增产效果的试验研究[期刊论文]-林业科技2005,30(5)

10. 孙忠奎.陈荣伟.王峰.付喜玲.张林 5种连翘的嫩枝扦插生根技术研究[期刊论文]-山东林业科技2011,41(2)

引证文献(1条)

1. 李汉伟 连翘种内变异的差异性分析[学位论文]硕士 2010

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