PROPAGATION AND CULTURAL REQUIREMENTS OF PRINSEPIA (PRINSEPIA SINENSIS (OLIV.) OLIV. EX BEAN)

Dissertation for the Degree of Ph. D.
MICHIGAN STATE UNIVERSITY
DAVID JAMES BEATTIE
1977

This is to certify that the

thesis entitled

Propagation and Cultural Requirements of
Prinsepia (*Prinsepia sinensis* (Oliv.) Oliv. EX Bean)

presented by

David James Beattie

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Horticulture

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Major professor

Date July 19, 1977

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ABSTRACT

PROPAGATION AND CULTURAL REQUIREMENTS OF PRINSEPIA (*PRINSEPIA SINENSIS* (OLIV.) OLIV. EX BEAN)

By

David James Beattie

Section I: Germination of Prinsepia (*Prinsepia sinensis* (Oliv.) Oliv. EX Bean): Effects of Stratification Time, GA Treatment, Temperature and Post Germination Chilling

Fresh or dry stored *Prinsepia sinensis* seeds with intact endocarp germinated satisfactorily although slowly, and chilling of seeds did not promote germination. Prolonged stratification decreased germination. However, if endocarps were removed from seed that had been stratified for 4 and 8 weeks and then had failed to germinate after 8 weeks, germination was complete within 2 weeks when seeds were held in the dark. GA_3 (100 or 500 ppm) hastened germination of seeds in the endocarp but did not increase final germination. Optimum germination temperature was 20°; germination was significantly lower at 15° and was practically nil at $25^{\circ}C$. Regardless of germination temperature, low temperature stratification, or the presence or absence of cotyledons, all seedlings were dwarf-rosetted in growth habit. Normal shoot elongation was restored only when seedlings were chilled for 14 or 21 days. While chilling slightly increased the number of leaves (nodes) per plant, the most noticeable effect of chilling was the marked increase in internode length. Scanning electron microscope examination of apical meristems showed limited development regardless of chilling. The presence of leaf primordia appeared to be of little importance in the resumption of normal shoot elongation.

Section II: Germination of Prinsepia (*Prinsepia sinensis* (Oliv.) Oliv. EX Bean): Interaction of Light, Seed Coat, and Temperature

Germination of prinsepia seed was inhibited by light. The effect was proportional to duration of light exposure after imbibition and decreased as time exposure was delayed. Photoreversible phytochrome was detected spectrophotometrically in etiolated seedlings, but not in imbibed seeds. Partial removal of seed coat increased percent germination and germination index in light; removal of the chalazal end was more effective than removal of the radicle end. Optimum germination temperature was 20°C in both light and darkness. Holding seeds at 10° for 1 to 2 weeks before transfer to 20° markedly reduced germination, while holding at 25°C did not.

Section III: Influence of Chilled and Nonchilled Scions and Rootstocks in Prinsepia (*Prinsepia sinensis* (Oliv.) Oliv. EX Bean)

Buds of nonchilled scions of *Prinsepia sinensis* were induced to grow when grafted on chilled rootstocks, and growth of chilled buds was depressed by grafting on nonchilled rootstocks. Nonchilled dwarf-rosetted scions grew when grafted on chilled rootstocks, but failed to grow when grafted on nonchilled rootstocks. These results suggest either the presence of a graft translocated stimulus, or lack of an inhibitor, of root origin that effects bud break.

Section IV: Effect of pH Regimes and N-Fertilization on Growth of Prinsepia (*Prinsepia sinensis* (Oliv.) Oliv. EX Bean)

Container grown plants of *Prinsepia sinensis* were supplied with 4 levels of nitrogen at media pH's of 4, 6, and 8 in a factorial design. As pH decreased, shoot and root dry weights increased significantly, while shoot:root ratios remained unchanged. As pH increased, shoot macroelements generally increased, and minor elements decreased. As N-level increased, stem dry weight and shoot:root ratio decreased significantly, while root dry weights did not at higher N-levels. As N-level increased, shoot N, Ca and Mn increased, while the levels of other elements remained unchanged.

PROPAGATION AND CULTURAL REQUIREMENTS OF PRINSEPIA (*PRINSEPIA SINENSIS* (OLIV.) OLIV. EX BEAN)

By

David James Beattie

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Horticulture

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ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Ronald L. Spangler for his guidance and support during the course of this graduate program.

Appreciation is also extended to members of the Guidance Committee - Dr. Harold Davidson, Dr. A. L. Kenworthy, Dr, James Kielbaso, and Dr. Dale Linvill - for their suggestions and help during this research.

Special gratitude is extended to Dr. Frank Dennis for his encouragement, patience, and helpful suggestions.

Gratitude is also extended to Dr. Michael Smith and Ms. Valerie Pearce for their assistance in collection and analysis of data, and to Dr. Kenneth Poff for his time and guidance in spectrophotometric phytochrome analysis.

Appreciation is also extended to Hidden Lake Gardens Trust Fund for financial support, without which this program would not have been possible.

Final gratitude is extended to my family whose patience and understanding made this graduate program possible.

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Guidance Committee:

The journal-article format was adopted for this dissertation in accordance with departmental and university requirements. Sections I and II were prepared and styled for publication in the Journal of the American Society for Horticultural Science while sections III and IV were prepared and styled for publication in HortScience.

LITERATURE REVIEW

Plant history. The genus Prinsepia was named by Royale in the 1830's to honor James Prinsep, an eminent British explorer-traveler. The half dozen or so species of this genera are shrubs, native to the Asiatic mainland, principally eastern China.

Prinsepia sinensis (Oliv.) Oliv., often called prinsepia or cherry prinsepia, is found growing in valley bottoms and along streams in Manchuria and N. Korea, where the climate is similar to that of central Michigan. According to Rehder (5), this hardy shrub (zone 4) has been cultivated since 1896. A mature prinsepia is about 3 meters high, has a dense growth habit, and makes an excellent barrier or hedge planting. However, it is mainly valued for its very early bright green foliage, normally appearing somewhat earlier than bush honeysuckle (Lonicera sp.) in East Lansing, Michigan. Masses of creamy yellow flowers (3-5 per node) bloom in April after leaf expansion has started. Numerous bright red, cherry-sized drupe fruits mature in late summer. The fruit is edible, but its tart taste makes it better suited for jellies.

Fruit is similar in appearance to cherry, but differs in a number of morphological and anatomical characteristics (2). The bulk of the embryo is cotyledonary tissue surrounded by a 2-layered seed coat or testa, enclosed in a woody, prominently fissured endocarp.

Taxonomists presently classify prinsepia in Rosaceae, but its position within that family is not definite. Some consider it to be a member of the subfamily Prunoideae. However, Sterling (8) recently placed it in a separate subfamily, Prinsepioideae, based on carpellary structure, ovule position, and floral symmetry, all of which differ from those of Prunoideae.

Prinsepia's dense growth habit, profuse flowering and edible fruit, lack of insect or disease pests, and early spring growth are desirable characteristics for a landscape shrub. However, prinsepia is seldom used as an ornamental, occurring mostly in arobreta and botanical gardens. According to Wyman (11), prinsepia "is a most serviceable plant and should be grown far more than it is". Prinsepia is not listed in nursery catalogs in Michigan and is probably not available commercially in the United States.

Normally, prinsepia seed germinate in late summer and early fall, and seedlings develop a dwarf-rosetted appearance. Plants resume normal growth the following spring. Ecologically, such a small slow growing shoot which develops a relatively large root system might better survive winter conditions.

Dormancy and rest. Plants have many physiological, biochemical and structural mechanisms that permit them to survive under unfavorable environmental conditions. In respone to either an adverse environment, or to genetic mechanisms that predetermine a response, plants enter a state of suspended growth, loosely referred to as dormancy. Literature about dormancy is vast, and the term itself open to many interpretations. Sussman and Havorson (9), who give the broadest possible definition, consider it to be a relative term describing a variety of conditions somewhere between the active vegetative state of growth and that of vitrification. Doorenbos (4) defines dormancy as "any case in which a tissue predisposed to elongate does not do so", whereas Samish (6), includes both quiescence and rest. Quiescence is exogenously controlled, and germination or growth will take place in a favorable environment. Rest, on the other hand, is controlled by endogenous factors such as metabolic blocks and growth inhibitors. During rest, growth or germination or bud growth will not occur even though environmental conditions are favorable. The most common method of overcoming rest is to expose buds, or moist seeds, to temperatures just above freezing for a number of weeks (6). This after-ripening process for seeds is usually referred to as stratification.

Seeds that would otherwise germinate may be rendered incapable of doing so under certain environmental conditions. Germination of fresh, ripe lettuce seed decreases rapidly if temperatures exceed 20°C (10). This condition is referred to as thermodormancy; decreases with time from seed harvest, or may be overcome by exposing the seed to light. Another type of temperature induced dormancy, called secondary dormancy, may be imposed in rose (7) or apple seeds (1) when transferred prematurely to temperatures of 25-30°C after part of their stratification requirement has been completed. To overcome secondary dormancy, seeds must be restratified. In all examples found in the literature, temperature induced dormancy always occurs in response to high temperatures, rather than low temperatures.

Successful crop production often involves removing or bypassing the resting state in buds or seeds. To do this, plants or seeds must be subjected to special environmental conditions, mainly combinations of light, moisture and temperature. Under these conditions, a number of metabolic events are synchronized, permitting the plant/seed to grow when the environment again becomes favorable. This study was undertaken to investigate and seek methods of overcoming rest in buds and seeds by subjecting them to various stratification (cool-moist after-ripening), temperature and light conditions, as well as growth regulators and seed coat removal. In addition, clonal plant response in container culture to various nitrogen levels and media pH was examined.

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SECTION I

Germination of Prinsepia (*Prinsepia sinensis* (Oliv.) Oliv. EX Bean): Effects of Stratification Time, GA Treatment, Temperature and Post Germination Chilling

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Additional index words. Dormancy, scanning electron microscope

Abstract. Fresh or dry stored *Prinsepia sinensis* seeds with intact endocarp germinated satisfactorily, although slowly, and chilling of seeds did not promote germination. Prolonged stratification decreased germination. However, if endocarps were removed from seed that had been stratified for 4 and 8 weeks and then had failed to germinate after 8 weeks, germination was completed within 2 weeks when seeds were held in the dark. GA_3 (100 or 500 ppm) hastened germination of seeds in the endocarp but did not increase final germination. Optimum germination temperature was 20°; germination was significantly lower at 15° and was practically nil at $25^{\circ}C$. Regardless of germination temperature, low temperature stratification, or the presence or absence of cotyledons, all seedlings were dwarf-rosetted in growth habit. Normal shoot elongation was restored only when seedlings were chilled. While chilling slightly increased the

> number of leaves (nodes) per plant, the most noticeable effect of chilling was the marked increase in internode length. Scanning electron microscope examination of apical meristems showed limited development regardless of chilling. The presence of leaf primordia appeared to be of little importance in the resumption of normal shoot elongation.

Stratification is required for normal seed germination of many woody perennials. Stratification requirements of many Rosaceous plants have been reported (4,6,7,8,10), but work with Prinsepia sinensis is limited. Wyman (22) obtained immediate germination if seeds were sown soon after fruit ripening in late summer. Fordham (14) found seed germinated well even after 14.5 months of dry storage.

One report (1) indicated germination was favored by stratification for 1 month at 4^{o} followed by 2 months at 22^{o}C, which implied prinsepia had a stratification requirement. While prinsepia germinated in response to a cool-warm storage regime (W. G. Ronald, personal communication), germination proceeded slowly over a period of months and seldom exceeded 50%, following such treatment.

Some growth promoters increase germination rate, or partially substitute for a stratification requirement. Soaking incompletely stratified Mazzard cherry seeds with intact endocarps in 100 ppm GA for 24 hr partially substituted for the normal stratification requirement (17). Peach seeds soaked in GA solutions for 24 hr after 35 days stratification germinated better than seeds which had not been treated with GA (9). In other studies, however, GA was ineffective on apple seeds (21) and peach seeds (4).

Some Rosaceous plants can be induced to germinate without stratification (2, 9, 10). Peach seeds produced plants if the embryo was excised (11). However, such plants usually rosetted, forming abnormally short internodes, and were referred to as physiological dwarfs. Because the shoot failed to elongate normally without chilling, Crocker and Barton (7) suggested this was an example of epicotyl dormancy, similar to that found in tree peony. The cause of this dwarfness was considered to be the same as that controlling bud dormancy in a normal plant (3, 12, 13) in that chilling restored normal growth (12, 19). During chilling of peach seeds, the epicotyl underwent considerable expansion and development, including the initiation of new leaf primordia (16). Ledbetter (16) hypothesized young expanding leaves were sources of growth factors responsible for normal internode extension.

Methods other than chilling reportedly produced normal seedlings from unstratified seed. Epicotyl dormancy in *Viburnum trilobum* (15) and *Quercus rubra* (5) was overcome by removing the cotyledons (15). Cox (15) proposed an inhibitor diffused from the cotyledons to the meristem, rendering it dormant.

Physiological dwarfness in peach was temperature dependent (18). When seeds are germinated at temperatures less than 20°C, normal seedlings develop. Pollock's observations agree with von Veh's (20) who obtained normal seedlings from several Rosaceous tree fruits when non-stratified embryos were germinated in 17-18°C.

Prinsepia seeds germinate out-of-doors in late summer and early fall. However, shoot elongation does not occur until the following spring, although buds expand or may form short internodes.

Since little is known about the stratification requirement of this seed, and preliminary experiments had shown germination to be slow and incomplete, our purpose was to determine how % germination might be increased. In addition, methods were sought to overcome or bypass the dwarf-rosetted stage of seedling development.

MATERIALS AND METHODS

Seed sources. Ripe Prinsepia sinensis fruit collected on the MSU campus in mid September were crushed and washed to separate the fleshy mesocarp from the woody endocarp. Seeds that floated in water were considered nonviable and discarded. Viable seed was kept moist for 24 hr until used. Additional dry seeds were obtained from Morden, Manitoba, Canada.

Stratification requirements. In order to determine the stratification requirement, lots of 25 seeds with endocarps were soaked in GA_3 solutions of 0, 100 and 500 ppm for 36 hr at 20°C, mixed with moist sphagnum peat moss sealed in plastic bags, and held for 0, 4, 8, or 16 weeks at 4 ± 2°C. Only one replicate was used per treatment. On removal from the medium, seeds were planted 5 mm deep in soil in 15 x 15 cm plastic trays, which were held under long day conditions. Night temperature was 20°, and occasionally reached 30°C during the day. Plants were watered as need with tap water. Germination was recorded when the hypocotyl hook became visible. Data were recorded weekly for 12 weeks.

In a second experiment, dry-stored seeds obtained from Morden, Manitoba, Canada were imbibed in distilled water for 24 hr, then stratified in moist sphagnum peat moss for 0, 2, 4, or 8 weeks. For each stratification time, 3 replicates of 20 seeds each were removed, surface sterilized for 10 min in a 1:10 dilution of $NaHClO_4$ (Clorox), and germinated in inverted 100 x 15 mm petri dishes on Whatman #3 filter paper moistened with distilled H_2O. Petri dishes were floated in a water bath adjusted so the temp at seed height was 20°C under continuous cool white fluorescent light of 8500 ergs $cm^{-2}sec^{-1}$. Observations were made weekly for 8 weeks, and germination was recorded when the radicle emerged from the endocarp. At the termination of the experiment, nongerminated seeds that had been stratified for 4 and 8 weeks were divided into 2 lots, and endocarps were removed from one lot. Seeds, with or without endocarp, were germinated in petri dishes as described above, except the dishes were wrapped in 2 layers of aluminum foil to exclude light. Germination was recorded under dim green light daily for 2 additional weeks. After seeds germinated, seedlings were planted in the greenhouse and maintained under conditions similar to those previously described.

In another experiment, the effects on germination of dry storage, stratification medium, and germination temp were determined. Dried seeds were stored in sealed containers at 5 ± 2°C. Freshly harvested seeds were stratified in moist sphagnum peat moss, in vermiculite, or on filter paper. After 16 weeks, dry seeds were vacuum infiltrated with distilled water for 4 hr, and all seeds were germinated in petri dishes as described above. Temp was maintained at 15, 20, or 25°C at seed level. Germination was recorded weekly for 8 weeks. Seeds were considered germinated when the radicle emerged from the endocarp.

Epicotyl dormancy. To determine if dwarfing could be prevented by chilling seed immediately after germination, dry-stored seed were removed from the endocarp, imbibed in darkness for 24 hr, and germinated in petri dishes in the dark at 20°C. After 14 days, 110 germinated seeds were stored at 4 ± 2°C for 9 days, then planted in 2 cm pots and grown in the greenhouse under long days for 2 months.

Another group of seeds was germinated in the same way. Post germination treatments consisted of either cotyledon removal, or chilling for 0, 7, 14, or 21 days at 4 ± 2^{0}C. After chilling, 4 replicates of 5 plants each were selected for uniformity, planted in 10 x 15 cm plastic trays, and grown in the greenhouse under long days. After 2 months, shoot length, leaf number, and shoot:root ratios were determined.

Scanning electron microscope study. Epicotyl development after chilling was determined by excising meristems from freshly germinated seeds,and seedlings that had been held for 6 weeks at 5 ± 2^{0}C. Meristems were placed in 3% glutaraldehyde (in .1M phosphate buffer) for 4 hr, then dehydrated in an 8-step alcohol series (10-100%, 20 min each). Samples were critical point dried (DPD Denton DCP-1) using liquid CO_2, mounted on SEM stubs with Tube Coat (G. C. Electronics, Rockford, Ill.), sputter coated with 20-40 nm of gold, and viewed in the SEM (International Scientific Instrument Co. Super Mini III). Accelerating voltage was 15KV.

RESULTS AND DISCUSSION

Stratification requirements. Seeds germinated slowly (Table 1), in agreement with data of Ronald (personal communication). Unlike his results, germination was maximal for unstratified seed after 12 weeks, and decreased markedly as stratification time increased. GA_3 treatment increased germination 2-5 times the control after 6 weeks in the greenhouse but little effect was noted after 12 weeks (Table 1).

Table 1. Effect of stratification at 4 ± 2°C and GA treatment on % germination of *Prinsepia sinensis* seed in soil. One replicate of 25 seeds was used per stratification time.

	% germination after:					
	6 (wk)			12 wk		
Stratification (wk)	GA (ppm)			GA (ppm)		
	0	100	500	0	100	500
0	24	60	56	86	86	96
4	40	-	-	72	-	-
8	12	20	20	48	72	64
12	4	-	-	24	-	-
16	0	0	0	16	16	12

Germination data after 6 weeks in the greenhouse indicated that the relative effectiveness of GA decreased the longer seeds were stratified. When seeds were stratified for 16 weeks, none germinated after 6 weeks and only 12-16% after 12 weeks. Rotting was not observed in the nongerminated seeds which had been stratified for 16 weeks, then held for 12 weeks in the greenhouse.

In a second experiment, stratification of dry seed for 0 or 2 weeks did not affect germination in the light at 20^0C, as 73% of both the stratified and nonstratified seeds germinated (data not shown). Seeds stratified for 4 or 8 weeks also failed to germinate after 8 weeks in the light at 20^0C. However, when endocarps were removed and seeds placed in the dark for 2 weeks, all seeds without endocarps germinated while those with endocarps did not germinate. Thus the endocarp restricts germination in some manner.

In testing the effect of germination temp, highest germination occured at 20^0 regardless of method of stratification (Table 2). Forty-six % germinated for all treatments at 20^0 compared to only 24% at 15^0 and 4% at 25^0C. Stratification medium did not significantly affect germination, but dry-stored seed germinated significantly better than did stratified seed, 75% germinating at 20^0C.

Epicotyl dormancy. Previous studies showed seedlings from stratified or nonstratified seeds, when greenhouse grown, were dwarf-rosetted. Neither cotyledon removal nor low germination temperature were effective in

Table 2. Effect of germination temp and method of stratification on the % germination of Prinsepia sinensis seed. Seeds were stratified at 4 ± 2°C for 16 wk, then held at indicated temp for 8 wk.[z]

	% germination				
	Stratification medium			Dry stored	
Germ temp (°C)	Filter paper	Vermiculite	Peat		Mean
15	17	17	26	36	24 b
20	29	42	38	75	46 c
25	2	4	0	8	4 a
Mean	16 m	21 m	21 m	40 n	

[z] Mean separation within sets by Duncan's multiple range test, 5% level.

preventing rosetting (Table 3, Fig. 1), and cotyledon removal reduced seedling vigor as determined by mean shoot length and leaves per plant. Only chilling after germination stimulated seedling shoot growth. Chilling germinated seeds for 14 and 21 days (Table 3) resulted in only 10% dwarfing. Failure of internodes to elongate was responsible for most of the dwarfing.

Leaves per plant tended to increase as chilling in creased (Table 3). However, the increase in the number of leaves per plant was modest, relative to the increased shoot: root ratio and shoot elongation (Table 3 and Fig. 2).

Therefore, elongation of internodes was primarily responsible for the increased shoot elongation, rather than increased number of internodes. This agreed with the findings of Ledbetter (16), who showed internodes of normal peach seedlings had more and larger pith cells than those of dwarfs.

<u>Scanning electron microscope study</u>. Unlike peach (16), in which leaf primordia increased during chilling, prinsepia epicotyls showed little development either before or as a result of chilling (Fig. 3).

These experiments indicate prinsepia seeds do not have a stratification requirment. Drying seed does not decrease germination, but may increase it. A high percentage of seed germinate slowly without stratification. Rapid and complete germination can be obtained within 2 weeks by removing the endocarp and germinating seed in the dark at 20^0C.

Table 3. Effects of germination temp, chilling after germination, cotyledon removal or chilling at 4 ± 2°C on leaf number, shoot length, shoot:root ratio, and growth habit in *Prinsepia sinensis* seedlings from nonchilled seeds.[z]

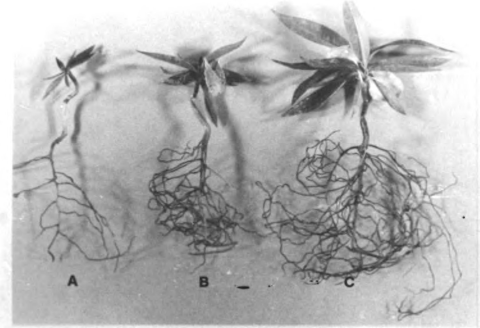
Germination temp (°C)	No. of cotyledons removed	Chilled after germination (days)	Dwarf plants (%)	Mean shoot length per plant (mm)	Leaves per plant	Shoot: root ratio
15	0	-	100	3.4ab	10.0bc	1.07a
20	2	-	100	(1.0)	(8.3)[y]	(1.35)
20	1	-	100	2.0a	8.8a	.99a
20	0	0	100	3.7ab	9.1ab	1.00a
20	0	7	95	6.8b	10.6cd	1.44b
20	0	14	10	19.6c	10.8de	1.52bc
20	0	21	10	22.0d	11.4e	1.58c

[y] 45% mortality, excluded from statistical analysis.

[z] Mean separation within columns by Duncan's multiple range test, 5% level.

Fig. 1. Effect of cotyledon removal after germination on seedling growth of *Prinsepia sinensis* after 6 wk. A = 2, B = 1, C = 0 cotyledons removed.

Fig. 2. Effect of chilling after germination on seedling growth of *Prinsepia sinensis* after 6 wk. A = 0, B = 7, C = 14, D = 21 days at 4 ± 2°C. Note internode elongation.



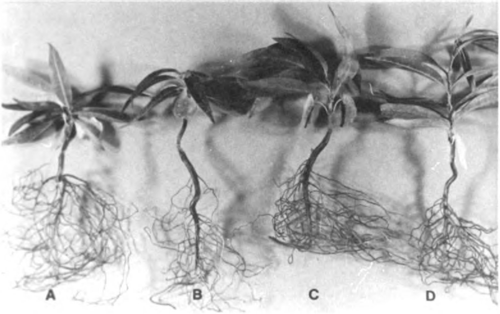


Fig. 1
Fig. 2

Fig. 3. Scanning electron micrograph of *Prinsepia sinensis* apices showing leaf primordia (lp) development in nonchilled (top) and chilled (bottom) plants.

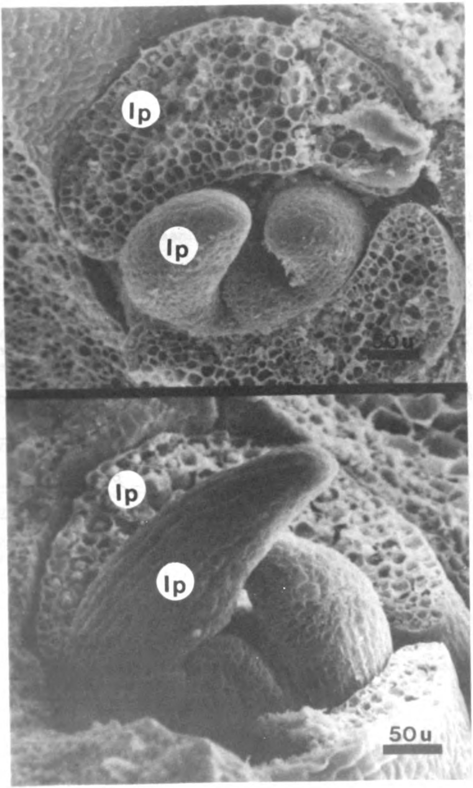


Fig. 3

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SECTION II

Germination of Prinsepia (*Prinsepia sinensis* (Oliv.) Oliv. EX Bean): Interaction of Light Seed Coat and Temperature

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Additional index words. Phytochrome, photoperiod, secondary dormancy

Abstract. Germination of prinsepia seed was inhibited by light. The effect was proportional to duration of light exposure after imbibition and decreased as time of exposure was delayed. Photoreversible phytochrome was detected spectrophotometrically in etiolated seedlings, but not in imbibed seeds. Partial removal of the seed coat increased percent germination and germination index in light; removal of the chalazal end was more effective than removal of the radicle end. Optimum germination temperature was 20°C in both light and darkness. Holding seeds at 10°C for 1 to 2 weeks before transfer to 20°C markedly reduced germination, while holding at 25°C did not.

Since its discovery, phytochrome (5,9,10) has been found to mediate the germination of a number of seeds. Germination of species including *Betula pubescens* (3),

paulonia tomentosa (6,30) and Pinus sylvestris (23) are light promoted while others, such as Phacelia tanacetifolia and Amaranthus caudatus (11,19) are light inhibited. However, we know of no references reporting light inhibited germination of woody perennials. Regardless of whether light is promotive or inhibitory, germination is thought to be controlled by the same phytochrome system. The difference occurs when seeds are exposed to white light (18). Light inhibited seeds are more sensitive to the far-red portion of the spectrum, which shifts phytochrome to the physiologically inactive form. Phytochrome must be in the far-red absorbing form to effect germination. This can be brought about by holding seeds to red light (17). Red/far-red photoreversibility has been demonstrated for both light promoted (5,23) and light inhibited seeds (17,20,21, 22,24,25).

Temp greatly modifies the photoperiodic/phytochrome response of some seeds, while it has little effect on others. Extensive reviews on this subject have been published by Toole (29) and Stokes (27). Black and Wareing (3) found freshly harvested seeds of Betula pubescens germinated only under long days at 15°C, but under either long or short days at 20°C. In Phacelia tanacetifolia, the inhibitory effect of light on germination was only slightly modified by low temp (4,11), while germination of Nemophila insignis seeds were unaffected by day length at high (30°C) temp (4). Schiebe and Lang (26) postulated that high temp may negate the red light effect on germination of 'Grand Rapids' lettuce by destroying phytochrome. Nyman (23) found the effects of red and far-red irradiation on the germination of Pinus sylvestris to be independent of temp.

The role of seed coverings in dormancy of seeds has been investigated, usually with seeds that have a stratification requirement for normal, rapid germination. Seed coats may inhibit or restrict water uptake (1, 34), oxygen exchange (31, 32, 34), or leaching of inhibitors (7, 33, 35). In addition, seed coats may restrict normal radicle emergence (12, 13, 14, 15).

Evenari and Newman (14) found 'Grand Rapids' lettuce germinated poorly in the dark. However, nearly 100% germinated in either light or dark if the seed coat and endosperm were removed from the radicle end of the seed.

Light inhibited germination of Phacelia tanacetifolia could be overcome by cutting or rupturing the seed coat at the radicle end (12). Cuts at other places, including small holes bored into the seed on either side of the radicle, were ineffective. When the embryonic axis was removed from the seed and cultured, it grew in either light or dark. Thus Chen and Thiman (12) concluded dormancy was due to mechanical restriction by seed coat, and not light.

Seeds of Prinsepia sinensis germinate rapidly if removed from the endocarp and held in the dark (2). The purpose of this study was to investigate the influence of light, temperature, and seed coat removal on germination.

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In addition, seeds and seedlings were examined for evidence of phytochrome.

MATERIALS AND METHODS

Germination conditions. Prinsepia sinensis seeds obtained from Morden, Manitobe, Canada were removed from the endocarp, imbibed in water in the dark for 24 hr, and surface sterilized for 10 min in a 1:10 dilution of $NaHClO_4$ (Clorox). Seeds were then placed in inverted 100 x 15 mm plastic petri dishes on distilled-water-soaked Whatman #3 filter paper. Three replicates of 10 seeds each were used for each treatment. Petri dishes were floated in water baths in a growth chamber maintained at $20 \pm 0.5^{o}C$. The light source was Sylvania Cool White VHO fluorescent lamps providing 8500 ergs $cm^{-2}sec^{-1}$ at seed height. To exclude light in some treatments, petri dishes were wrapped in 2 layers of aluminum foil. Germination was recorded daily for 2 weeks. Dark germinated seeds were counted under dim green light. Seeds were considered germinated when the radicle had emerged 1-2 mm. Germination index was calculated as the cumulative number of seeds germinated on each observation. Analysis of variance was used to determine the statistical significance of observed differences.

Effect of time of exposure to light. To test the effect of length of exposure to white light, seeds were exposed to light for 12, 24, or 48 hr after imbibition,

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then returned to darkness (Fig. 1). Controls were germinated in both continuous light and continuous dark. The effect of a single 24 hr exposure given 1 to 5 days after imbibition was determined. Seeds were maintained in the dark except for this one 24 hr period. Control seeds were held both in continuous light and continuous dark. Many seeds are photoperiodic (16), but some have no critical photoperiod (4). To determine if prinsepia had a critical photoperiod, seeds were exposed to white light for periods of 0, 1.25, 2.5, 5.0, 10.0, or 20 hr each day for 14 consecutive days. Two replications of 10 seeds each were used. Seeds from a second seed source were exposed to 0, 1.25, 2.5, and 5.0 hrs of white light each day.

Effect of seed coat removal. Seed coats were wholly or partially removed from, or left intact, prior to germination in constant white light or darkness. About 1 mm^2 of the seed coat was removed from either the chalazal or radicle end of the seed.

Effect of germination temp. Optimum germination temp for seeds with intact endocarp was 20^oC (2). To determine whether light modified the response to temp, seeds were removed from the endocarp and germinated at 15^o, 20^o or 25^oC.

Induction of secondary dormancy. Many seeds, including lettuce, enter a state of secondary dormancy when exposed to high temp (28). Long periods of stratification may induce secondary dormancy in prinsepia seed (2). To determine whether this was an instance of secondary dormancy, seeds

Fig. 1. Time of exposure to light at different intervals (top) or for different periods of time (bottom) after 24 hours imbibition (I) for *Prinsepia sinensis* seed.

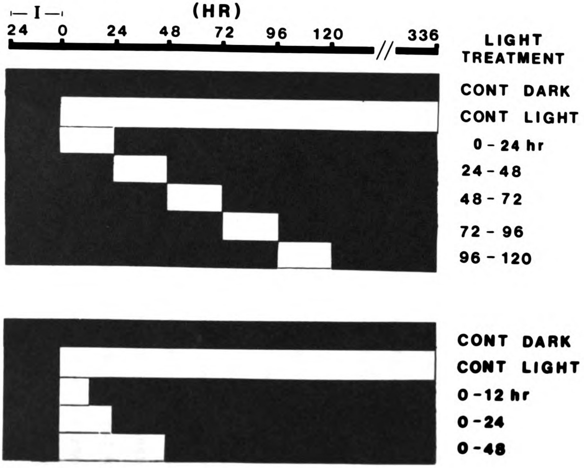
I
(HR)
24
0
24
48
72
96
120
336
LIGHT TREATMENT
CONT DARK
CONT LIGHT
0 - 24 hr
24 - 48
48 - 72
72 - 96
96 - 120
CONT DARK
CONT LIGHT
0 -12 hr
0 -24
0 -48

Fig. 1

were removed from the endocarp, dark imbibed for 24 hr at 20°, placed for 2 weeks in the dark at either 25° or 10°, then returned to 20°C. Germination counts were made daily for 1 week. Each treatment included 3 replicates of 10 seeds each. The experiment was repeated using 2 replicates of 9 seeds each, with seeds remaining at 25° and 10° for only 1 week before transfer to 20°C.

Presence of phytochrome. Seeds were germinated in the dark at 20°C for 20 days. When radicles were 3 cm long, the root-hypocotyl section was separated from the cotyledons under dim green light, finely chopped, moistened with distilled water, and placed in a cuvette. For detection of seed phytochrome, seeds with intact seed coats were dark imbibed at 20° for 1 to 7 days. Absorption spectra were measured on a single beam spectrophotometer similar to that described by Butler (8), and on line with a Hewlitt-Packard 2108 MX computer. Wavelength accuracy was calibrated to 0.1 nm with a mercury lamp having a spectral band width of less than 2 nm. Samples were scanned between 200 and 800 nm. A total of 512 readings were taken every 0.2 nm and stored in the computer and averaged. For each curve, at least 2 independent spectra were measured on the same sample. When a part of such spectra showed differences other than random noise, they were discarded. The difference between absorbance of the sample and that of a reference blank were read out directly from the computer into an X-Y recorder. To test photoreversibility, samples were irradiated for 2 min

with light from an incandescent microscope lamp. Red and far-red irradiation were generated by passing the light through interference filters and a 5 cm water filter. The red filter had a 10.8 nm half band width at 50% transmission, while the far-red half band width was 12 min. Light intensity at sample height was 2000 ergs $cm^{-2}sec^{-1}$ red for 1250 ergs $cm^{-2}sec^{-1}$ far-red. Prior to irradiation for absorption analysis, samples were irradiated with 5 min of red light followed by 60 min of dark. This insured phototransformation of protochlorophylls to forms whose absorbance spectra were not similar to those of Pr phytochrome.

RESULTS AND DISCUSSION

Effect of time of exposure to light. The rate of germination of Prinsepia sinensis seed declined with increasing exposure to light (Table 1). However, light appeared to only retard germination, as all seeds except those held in continuous light germinated between 95 and 100%.

The greater the time interval between imbibition and light exposure, the greater the germination index (Table 2), while % germination was not significantly different. As in the previous experiment, the lowest germination occurred under continuous light. Germination varied inversely with length of the photoperiod, except at 1.25 and 2.5 hr (Fig. 2), suggesting a quantitative effect of

Tabl

Table 1. Effect of length of exposure to continuous white light given after 24 hr imbibition on the final % germination and germination index after 14 days on <u>Prinsepia</u> <u>sinensis</u> seed removed from the endocarp.[y]

Light (hr)	Germination	
	Final %	Index[z]
0	100%	82 d
12	95	67 c
24	100	61 bc
48	100	58 b
336	10	6 a

[y] Mean separation within column by Duncan's multiple range test, 5% level.

[z] Cumulative no. of seeds germinated on each of days 4-14.

Tabl

Table 2. Effect of time of exposure to 24 hr light following imbibition on the final % germination and germination index after 14 days on *Prinsepia sinensis* seed removed from endocarp.[z]

Treatment	Germination Final %	Germination Index[y]
Control		
Cont light	10 a	5 a
Cont dark	93 b	80 f
Light at (hr)		
0-24	83 b	44 b
24-48	76 b	44 b
48-72	86 b	55 c
72-96	90 b	64 d
96-120	93 b	72 e

[y] Mean separation by Duncan's multiple range test, 5% level.

[z] Cumulative no. of seeds germinated on each of days 4-14.

Fig. 2. Effect of day length on the % germination of *Prinsepia sinensis*. Light treatments applied during days 1-14 following inbibition. Mean separation by Duncan's multiple range test, 5% level.

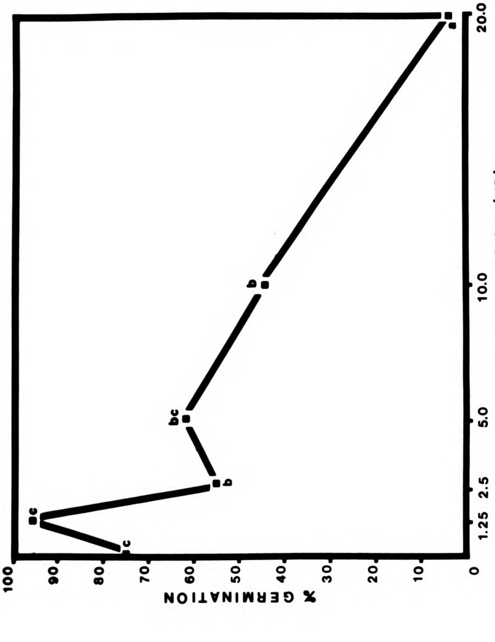
% GERMINATION
100
90
80
70
60
50
40
30
20
10
0
1.25
2.5
5.0
10.0
20.0
DAILY LIGHT PERIOD (HR)
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Fig. 2

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of light. On repeating the experiment, parallel data were obtained for 0. 1.25, 2.5, and 5 hr; however, differences were not statistically significant.

<u>Effect of seed coat removal</u>. The presence of a seed coat inhibited % germiantion in light but not in dark, while seed coat removal improved the index of germination in both light and dark (Fig. 3.) Light x seed coat interaction was significant at 1%. Light, independent of seed coat removal, inhibited while dark promoted germination. Light was more inhibitory in the presence of a seed coat, although germination index was promoted by seed coat removal in the dark. Removal of the seed coat at the chalazal or radicle end of the seed increased % germination and germination index in the light, but had less effect in the dark (Fig. 4.) Light x seed coat removal was significant at the 1% level so that dark, independent of seed coat removal, promoted germination while light inhibited germination. Chalazal end seed coat removal resulted in significantly higher % germination and germination index than did radicle end removal or intact seed coats.

It is not known if prinsepia seed coats inhibit normal water uptake and expansion of the embryo as in lettuce seed (14), but it is suggested by the promotive effect of partial seed coat removal, especially dark germinated seeds (Fig. 4.). There was little promotive effect where seed coat was removed at the radicle end and light germinated while chalazal end removal resulted in good germination percentage in either light or dark.

Fig. 3. Effect of continuous white light or dark and seed coat removal on the % germination (top) and germination index (bottom) after 14 days on *Prinsepia sinensis* removed from endocarp. Index based on sum of cumulative no. of seeds germinated on each of days 7, 10 and 14. Bars accompanied by the same letter are not significantly different by Duncan's multiple range test, 5% level

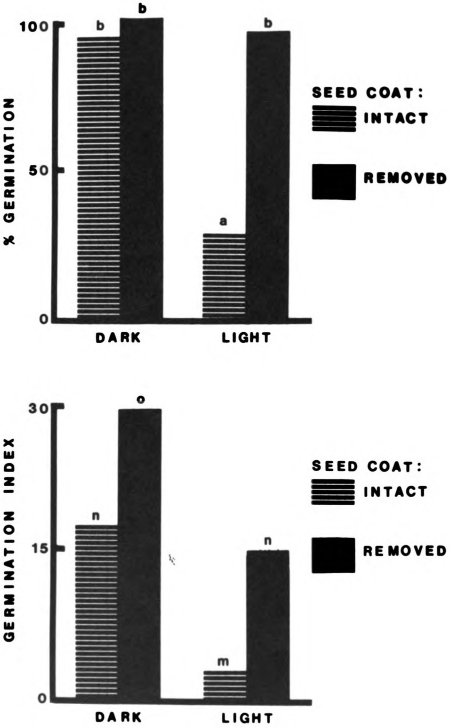
% GERMINATION
100
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Fig. 3

Fig. 4. Effect of continuous white light or dark and seed coat removal from either the radicle or chalazal end of the seed on the % germination (top) and germination index (bottom) after 14 days on _Prinsepia sinensis_ seed removed from endocarp. Index determined from the cumulative no. of seeds germinated on each of days 4-14. Bars accompanied by the same letter are not significantly different by Duncan's multiple range test, 5% level.

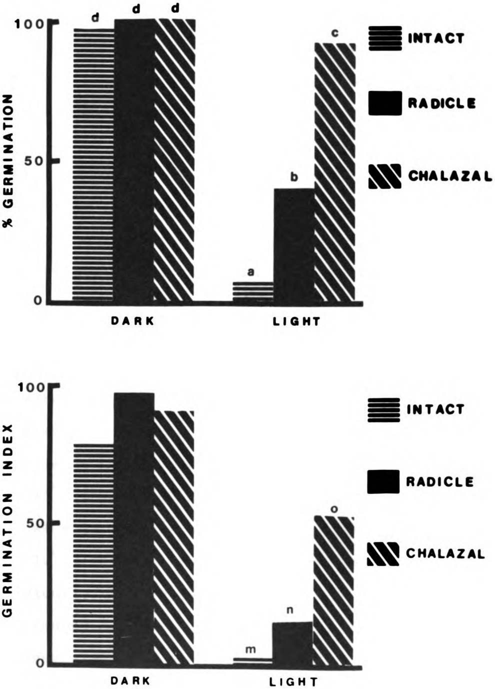
% GERMINATION
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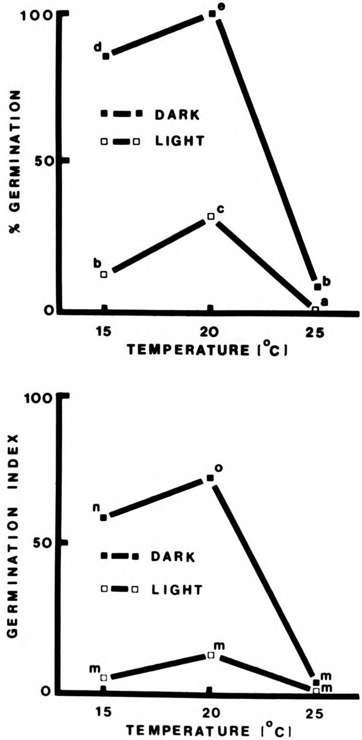
Fig. 4

Effect of germination temp. In either light or dark, % germination increased between 15^0 and 20^0 and dropped markedly at 25^0C (Fig. 5). Index was also increased in the dark between 15^0 and 20^0, dropping markedly at 25^0C, but there was no difference in index amoung germination temp in the light. A light x temp interaction was significant at 1%. Index and % germination were dark promoted and light inhibited. Optimum germination temp of 20^0 C agreed with the results reported earlier for seeds with intact endocarps (2). Unlike the findings of Black and Wareing (3), and Schiebe and Lang (26), temp did not completely obviate the light effect on germination % but did so for germination index.

Induction of secondary dormancy. Ten % of seeds held in the dark for 2 weeks at 25^0 germinated, while none of those held at 10^0C germinated (data not shown). When nongerminated seeds were transferred to 20^0 for 1 week, 100 % of the seeds previously held at 25^0 vs. only 37% of those held at 10^0C germinated. On transfer to 20^0, germination after 1 week was 96% and 4% for seeds previously held at 25^0 and 10^0C, respectively. At both 25^0 and 10^0C, seeds were obviously thermodormant.

Dormancy appears to be transitory for the 25^0 seeds as they germinate readily when returned to 20^0C. However, dormancy in the 10^0C seeds is much deeper. These results

Fig. 5. Effect of continuous white light or dark and temp on the % germination (top) and germination index (bottom) after 14 days on Prinsepia sinensis seed removed from endocarp. Index was determined from the cumulative no. of seeds germinated on each of days 4-14. Data points accompanied by the same letter are not significantly different by Duncan's multiple range test, 5% level.



100
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% GERMINATION
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TEMPERATURE (°C)
100
50
0
GERMINATION INDEX
n
o
m
m
m
m
DARK
LIGHT
15
20
25
TEMPERATURE (°C)

Fig. 5

may, in part, explain why germination of prinsepia seeds in the endocarp declined as stratification was prolonged (2).

Phytochrome. Photoreversible phytochrome was detected repeatedly in etiolated seedlings. Fig. 6 is a sample difference spectrum illustrating photoreversibility. However, attempts to detect phytochrome in imbibed cells were unsuccessful.

Fig. 6. Far-red minus red difference spectrum of etiolated <u>Prinsepia sinensis</u> seedling hypocotyls.

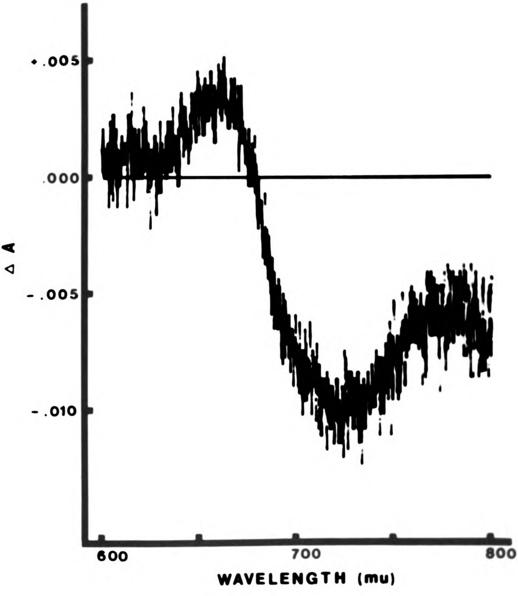
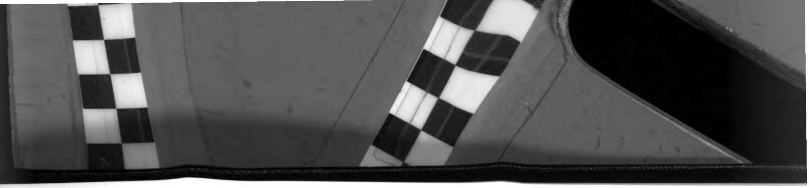


Fig. 6



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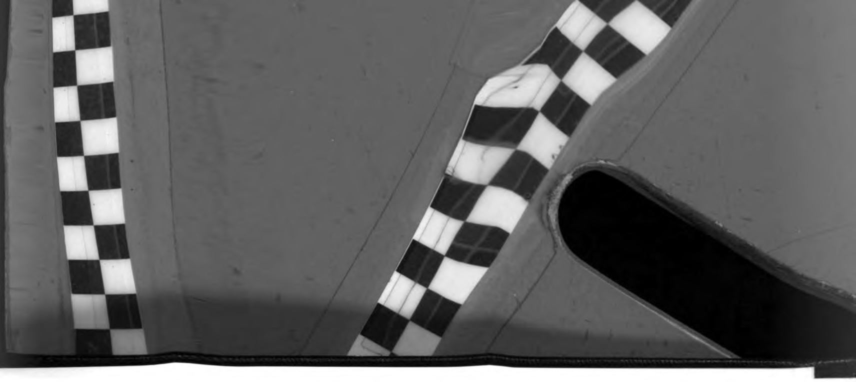

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Infl

Influence of Chilled and Nonchilled Scions and Rootstocks on Bud Dormancy in Prinsepia (*Prinsepia sinensis* (Oliv.) Oliv. EX Bean)

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Additional index words. Chilling

Abstract. Buds of nonchilled scions of *Prinsepia sinensis* were induced to grow when grafted on chilled rootstocks, and growth of chilled buds was depressed by grafting on nonchilled rootstocks. Nonchilled dwarf-rosetted scions grew when grafted on nonchilled rootstocks, but failed to grow when grafted on nonchilled rootstocks. These results suggest either the presence of a graft translocated stimulus, or lack of an inhibitor, of root origin that effects bud break.

Grafting experiments are used to examine the role of translocatable stimulii involved in bud dormancy. Westwood and Chestnut (5) made reciprocal grafts of pear species having long (*Pyrus communis* 'Bartlett') vs. short (*Pyrus calleryana*) chill requirements to determine the respective effects of scion vs. rootstock on bud dormancy. 'Bartlett' scions grafted to *P. calleryana* rootstocks required fewer chilling hours for growth than did nongrafted 'Bartlett'. Grafting actively growing *P. calleryana* scions on the same bra

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branch with partially chilled 'Bartlett' buds stimulated growth of the latter, while growth of 'Bartlett' buds depressed by grafting onto partially chilled rootstocks. For these results, the authors hypothesized the presence of a translocatable stimulus involved in rest. Chandler (1) grafted chilled apple scions onto chilled and nonchilled rootstocks. Growth was normal on chilled, but poor on nonchilled rootstocks. Nienstaedt (3) side grafted nonchilled white spruce scions onto chilled and nonchilled Norway and white spruce rootstocks. After one season, scions had grown slightly more on chilled than on nonchilled rootstocks. Nesterov (4) observed little shoot growth when nonchilled apple and plum scions were grafted onto young chilled trees of the same species. However, nonchilled scions grew vigorously when grafted onto older stumps, which would suggest either a root system volume or age effect. Chilled scions grew poorly when grafted onto dormant rootstocks. Excised peach embryos germinated without chilling, but seedlings remained dwarf. Flemion (2) could not induce normal growth by grafting these seedlings on actively growing normal seedlings and concluded that the site of this type of dormancy was in the shoot.

Prinsepia stops growing in June at a time when many other plants are still actively growing. Preliminary experiments showed shoot tip removal, extended photoperiod, or heat treatment had little effect on inducing bud break once terminal growth had ceased. The purpose of this study was to determine if bud dormancy could be influenced by grafting.

All grafts were made with plants of a single clone except dwarf-rosetted plants propagated from seed. Plants were potted in either 5 or 12 cm pots. Prior to grafting, chilled plants were held at 4 ± 2^{0}C for 1500 hr. During this time, all leaves abscissed. Unchilled plants were considered in the initial stages of rest. Plants had been maintained under long-days (interrupted nights) in a greenhouse and had ceased growth 4 months prior to grafting. Side grafts were prepared by inserting a 3-bud scion (taken from the median 1/3 of the donor plant) into the lower 1/3 of the rootstock stem. Excess rootstock was removed 1 cm above the graft. For inarching grafts, the rootstock and scion plants were removed from pots and approach grafted on the lower 1/3 of their stems. The inarched graft combination was replanted in a single pot. All grafts were wrapped with grafting rubbers, and plants were shaded and misted as necessary until grafts had knitted. Nonchilled check plants were cut back to 1/3 their original size and defoliated. Following chilling, chilled stock plants were cut back to 3 buds immediately above soil level. Plants were maintained under long days (nights interrupted with 4 hr incandescent light) with night temp of 20^{0} and daytime temp of 20^{0} to 30^{0}C.

When nonchilled rootstock (whole) plants were pruned and defoliated, they grew very little, whereas buds of nonc

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nonchilled scions grew vigorously when grafted on chilled rootstocks (Table 1). However, when buds of chilled scions were side grafted on a nonchilled rootstock, some buds broke and grew, but shoot growth was only 15% of that on the chilled rootstock plant. Inarching of nonchilled rootstock plants to chilled scion plants similarly depressed scion bud growth.

Similar results occured with smaller plants grown in 5 cm pots (Tables 2 & 3). Buds failed to grow on nonchilled rootstock plants (Table 2), whereas inarching chilled scion plants to chilled rootstock plants induced growth similar to that of chilled (ungrafted) rootstock plants. Grafting together 2 chilled plants stimulated growth (Table 2), probable due to the presence of 2 root systems. A smaller increase was noted when these treatments were repeated (Table 3). Also, when a nonchilled rootstock was inarched into a chilled scion plant, shoot growth was depressed about 50%, considerable more than the 20% depression noted in Table 2. When chilled rootstock plants were inarched onto nonchilled scion plants, buds broke, but growth was only 15 % that of the chilled rootstock and little more than the nonchilled rootstock. The reason for this is unclear, especially when bud break and vigorous growth occured in this same graft combinatoin in Tables 1 & 2.

When scions from nonchilled, dwarf-rosetted seedlings were grafted on chilled and nonchilled rootstocks, an avg of 2.5 nonchilled scion buds per plant grew an avg 256 mm in

Table 1. Effect of inarch and side grafts on scion bud break and shoot growth of *Prinsepia sinensis* after 6 wk growing in 12 cm pots.

Scion/rootstock	No of grafts	No of plants	Scion bud break (%)	Avg growth per scion bud (mm)
Whole plants^{z}				
Chilled rootstock	-	10	93	274
Nonchilled rootstock	-	15	4	16
Inarch grafted				
Chilled/nonchilled	10	-	94	223
Nonchilled/chilled	10	-	87	121
Side grafted				
Nonchilled/chilled	20	-	76	125
Chilled/nonchilled	15	-	44	44
Nonchilled/nonchilled	5	-	20	12

[z] Pruned and defoliated.

Table 2. Effect of inarch grafts on scion bud break and shoot growth of *Prinsepia sinensis* after 6 wk growing in 5 cm pots.

Scion/rootstock	No of grafts	No of plants	Scion bud break (%)	Avg growth per scion bud (mm)
Whole plants[z]				
Chilled rootstocks	-	15	90	64
Nonchilled rootstocks	-	15	0	0
Inarch grafted				
Nonchilled/chilled	6	-	83	57
Chilled/chilled	6	-	77	83

[z] Pruned and defoliated.

Table 3. Effect of inarch grafts on scion bud break and growth of *Prinsepia sinensis* after 6 wk growing in 5 cm pots.

Scion/rootstock	No of grafts	No of plants	Scion bud break (%)	Avg growth per scion bud (mm)
Whole plants[z]				
Chilled rootstock	15	-	96	123
Nonchilled rootstock	15	-	27	13
Inarch grafted				
Chilled/chilled	-	15	91	132
Chilled/nonchilled	-	15	82	76
Nonchilled/chilled	-	15	38	18
Nonchilled/nonchilled	-	15	33	13

[z] Pruned and defoliated.

length, whereas only .5 of the nonchilled scion buds grew less than 2 mm (Fig. 1).

While graft results with prinsepia are not complete, they appear to support Westwood and Chestnut's (5) hypothesis that a graft translocated stimulus of root origin is involved in breaking dormancy, and does not support Flemion's (2) belief that the site of dormancy is in the shoot, especially for dwarf-rosetted seedlings.

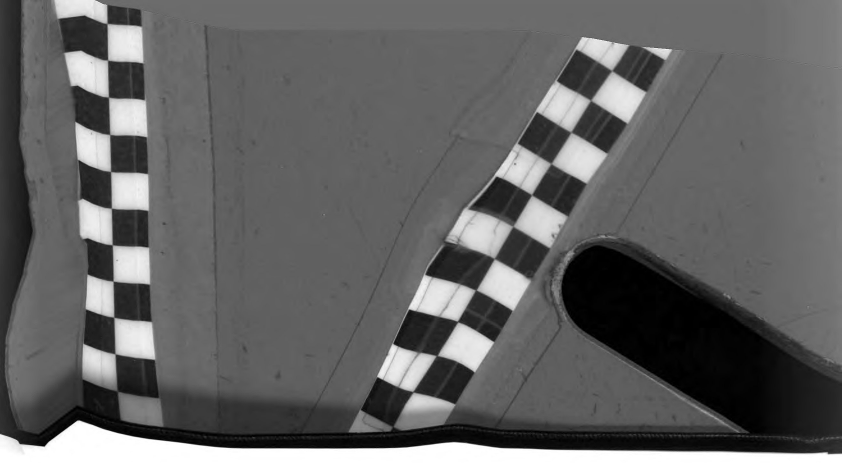


Fig. 1. Effect of grafing nonchilled dwarf-rosetted scions on chilled (left) and nonchilled (right) rootstocks or *Prinsepia sinensis*

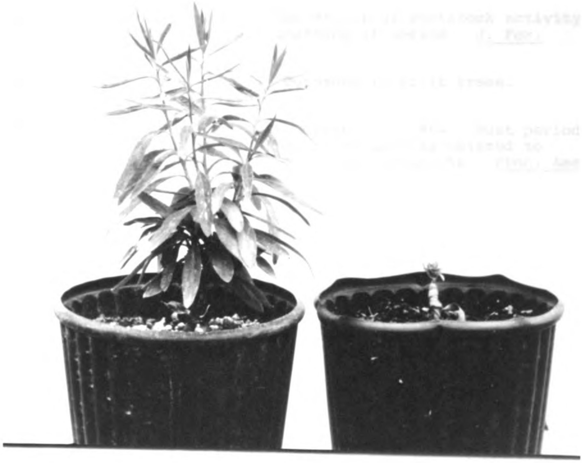
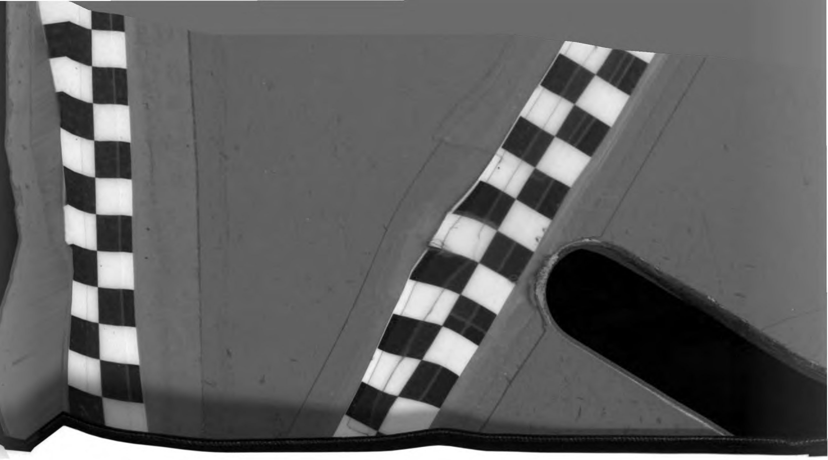


Fig. 1



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SECTION IV

Effect of pH Regimes and N-fertilization on Growth of Prinsepia (Prinsepia sinensis (Oliv.) Oliv. EX Bean)

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Additional index words. Mineral nutrition, dry weight

Abstract. Container grown plants of Prinsepia sinensis were supplied with 4 levels of nitrogen at media pH of 4, 6, and 8 in a factorial design. As pH decreased, shoot and root dry weights increased significantly, while shoot:root ratio remained unchanged. As pH increased, shoot macroelements generally increased, and minor elements decreased. As N-level increased, stem dry weights did not at higher N-levels. As N-level increased, shoot N, Ca and Mn increased, while the levels of other elements remained unchanged.

Some unusual ornamental plant materials are seldom used for a lack of information about their culture. Prinsepia sinensis, commonly called prinsepia, is a good example. A mature prinsepia is about 3 m high with thorny twigs and a dense growth habit, making it a valuable hedge or barrier plant. Prinsepia is one of the first plants to leaf out in the spring and is quickly covered with masses of yellowish flowers. Numerous edible cherry-sized fruits mature in late summer and are eaten by a variety of wildlife. Prinsepia is native to North Korea and Manchuria and is reliably hardy as far north as Morden, Manitoba, Canada. Although it has been cultivated since the late 1800's, little information is currently available about its culture and, in particular, nutrient requirements. One method of establishing general guidelines for crops about which little is known is to grow them in containers (2).

Production of woody ornamentals in containers is becoming an increasingly popular nursery practice. Advantages include the relative ease with which media pH can be adjusted and nutrient levels controlled. A preliminary study in 1975 indicated that prinsepia responded to high nitrogen fertilization. Since soil or media pH largely determines efficiency of nutrient uptake, an experiment was designed to determine the effect of both pH and N-fertilization on growth of Prinsepia sinensis.

Well-rooted clonal cuttings of prinsepia were planted in 1 liter plastic nursery containers containing a steam-pasteurized medium consisting of equal vol of sphagnum peat moss, horticultural grade perlite and sandy loam to which was added triple superphosphate (45% P_2O_5) at the rate of 1.7 kg/m^3. Treatments consisted of a factorial combination of 4 conc of N and 3 media pH levels. Four replicates of 7 uniform plants each were arranged in a randomized block design. Media pH levels were 4, 6 and 8. Based on soil

titrations, pH (6 initially) was adjusted to 4 by addition of concd H_2SO_4, and to pH 8 by adding CaO. At each fertilization, 375 ppm K was supplied as fertilizer grade KCl, and 0, 400, 800, or 1200 ppm N as fertilizer grade NH_4NO_3. Solutions (150 ml per container) were applied weekly from May 20 to September 9, 1976. Between fertilizations, containers were watered daily with 125 ml of water supplied by a modified microtube irrigation system. At harvest, a soil sample was taken from each pot, mixed, and final media pH was measured. Tops were separated from roots and each was dried in a forced draft oven. After recording dry wt, samples were ground in a Wiley Mill to pass a 40 mesh sieve, and analyzed for macro and minor elements. N was determined by Macro-Kjeldahl (1), K by flame spectrophotometry (Beckman model B), and other elements on a spark emission spectrograph (Applied Research Laboratories Quantograph (3)).

Final media pH ranged from 7.8 to 8.1, presumably due to the irrigation water which had a pH of 8.1. A greater range in final pH was found in response to N-fertilization, varying from 7.6 at 1200 ppm N to 8.2 for 0 N. These data reflect, in part, the acid reaction produced by nitrification of the ammonium ion in NH_4NO_3.

Max dry wt production occurred with initial pH of 4 and 1200 ppm N. Shoot and root dry wt was halved as pH increased from 4 to 8 (Table 1). Shoot wt doubled as N levels increased from 0 to 1200 ppm, but root dry wt did not increase titrations, pH (6 initially) was adjusted to 4 by addition of concd H_2SO_4, and to pH 8 by adding CaO. At each fertilization, 375 ppm K was supplied as fertilizer grade KCl, and 0, 400, 800, or 1200 ppm N as fertilizer grade NH_4NO_3. Solutions (150 ml per container) were applied weekly from May 20 to September 9, 1976. Between fertilizations, containers were watered daily with 125 ml of water supplied by a modified microtube irrigation system. At harvest, a soil sample was taken from each pot, mixed, and final media pH was measured. Tops were separated from roots and each was dried in a forced draft oven. After recording dry wt, samples were ground in a Wiley Mill to pass a 40 mesh sieve, and analyzed for macro and minor elements. N was determined by Macro-Kjeldahl (1), K by flame spectrophotometry (Beckman model B), and other elements on a spark emission spectrograph (Applied Research Laboratories Quantograph (3)).

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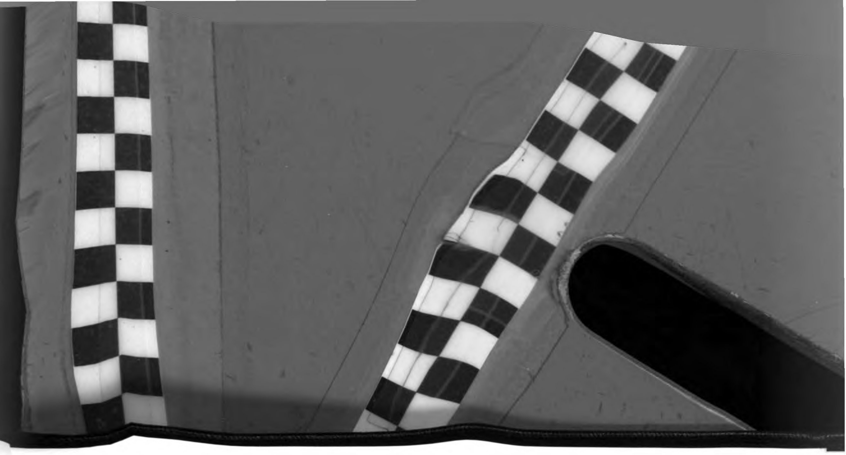
Max dry wt production occurred with initial pH of 4 and 1200 ppm N. Shoot and root dry wt was halved as pH increased from 4 to 8 (Table 1). Shoot wt doubled as N levels increased from 0 to 1200 ppm, but root dry wt did not increase

Table 1. Main effects of pH and N levels on dry wt and shoot:root ratio of *Prinsepia sinensis* plants.[z]

Treatment	Final pH	Dry wt per plant (g)		Shoot:root ratio
		Shoot	Root	
pH				
4	7.8	14.8c	22.3c	0.63a
6	8.0	10.1b	15.7b	0.63a
8	8.1	6.6a	11.0a	0.58a
N(ppm)[y]				
0		4.79a	12.4a	0.51a
400		6.72b	16.8b	0.61b
800		7.35b	18.3b	0.64bc
1200		7.70	17.8b	0.70c

[z] Mean separation within columns and sets by Duncan's multiple range test, 5% level. Interaction was not significant at the 5% level.

[y] Supplied as NH_4NO_3



significantly above the 400 ppm fertilizer level. Shoot:root ratio also increased.

As might be expected, plant N increased as N levels increased (Table 2), apparently the rate of N uptake was not saturated at the highest N levels. Although the max level of N used in this study (1200 ppm) may be considered extremely high, plants were able to utilize it. However, the ammonium may not have been used at all, response being due primarily to the presence of nitrate. Plant K and P uptake did not increase above the 400 ppm N level.

As soil pH increases, major nutrients like N, P, K, Ca, and Mg generally become more available, while minor elements become less available (4). In this experiment, plant N and Ca increased with pH, K and Mg increased slightly, and P remained relatively unchanged. Fe deficiency is often associated with increased pH (4), but in prinsepia, plant Fe actually increased with pH. Mn decreased while the level of other minor elements remained stable.

From this study, we conclude that container grown prinsepia grew best at a relatively low pH with a high supply of N. Because media pH was not controlled after the initial adjustment, maximum growth may not have been attained. Additional work will be required to establish the optimum pH.

Table 2. Main effects of pH and nitrogen on nutrient levels in shoots of *Prinsepia sinensis*.[z]

Treatment	N	K	P	Ca	Mg	Mn	Fe	Cu	B	Zn	Al
			(%)						(%)		
pH											
4	1.73a	.65a	.10b	1.01a	.33a	176b	254a	3.7a	29.1a	28.5a	184a
6	1.80ab	.66a	.09a	1.07b	.39b	84a	264b	3.7a	30.2a	32.0ab	203a
8	1.86b	.70b	.10b	1.31c	.37b	82a	280c	2.8a	33.2a	33.8b	199a
N (ppm)[y]											
0	1.17a	.60a	.10b	0.99a	.34a	77a	268ab	3.4a	30.4a	28.7a	213a
400	1.78b	.70b	.08a	1.13b	.37b	88a	244a	3.7a	30.6a	32.1a	184a
800	2.01c	.67b	.09b	1.16bc	.37b	112b	275ab	3.3a	30.1a	31.7a	196a
1200	2.22d	.70b	.10b	1.23c	.38b	178c	277b	3.2a	32.3a	33.3a	188a

[z] Mean separation within columns and sets by Duncan's multiple range test, 5% level. Interaction was not significant at the 5% level.

[y] N supplied as NH_4NO_3.

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SUMMARY

Botanical gardens and arboreta abound with plants that are seldom used, but have potential landscape value. For example, Prinsepia sinensis has been known in cultivation since the late 1800's but has never "caught on". However, research in this laboratory has clarified some of the conflicting and incomplete reports about its propagation and culture.

Fresh or dry-stored prinsepia seeds with intact endocarps germinate satisfactorily although slowly. Prolonged stratification sharply reduced germination. Presence of an endocarp may have been in part responsible for this. Seeds with intact endocarps stratified for 4 and 8 weeks that did not germinate after 8 weeks, did so within 2 weeks when then removed removed from the endocarp and germinated in the dark. Soaking in GA solutions (100 and 500 ppm) hastened germination of seeds in the endocarp, but did not affect final germination %. Optimum germination temp for seeds with or without endocarp was 20°; decreased significantly at 15° and practically nil at 25°C. Holding seeds at 10° for 1-2 weeks before transfer to 20° markedly reduced germination, while holding seeds at 25°C did not. When removed from the endocarp, seed germination is inhibited by

light. Partial seed coat removal increased germination in the light, removal at the chalazal end being more effective than at the radicle end. Light inhibition of intact seeds removed from the endocarp was proportional to the duration of exposure and decreased as the time of exposure was delayed. Photoreversible phytochrome was detected spectrophotometrically in etiolated seedlings but not in imbibed seeds.

Seeds from chilled or nonchilled seeds were dwarf-rosetted in growth habit. Normal shoot elongation occured only when seedlings were chilled. The most noticable effect of chilling was on internode elongation. Scanning electron microscope examination of seedlings showed no significant change in apical morphology as a result of chilling.

While some of the basic environmental factors affect prinsepia seed germination, more work is needed to obtain more rapid germination from seeds with intact endocarps. In addition, further studies should examine whether light affects germination of seeds with intact endocarps, as well as to establish the physiological basis for the anomolous low-temp induced secondary dormancy.

Prinsepia stops growing early in June when other plant are still actively growing. Once growth has ceased, extended photoperiod, heat treatment, or removing the shoot tip has little or no effect on bud break. However, nonchilled buds were induced to grow when grafted onto chilled rootstocks. Further grafting experiments are needed to

clairfy the relative influence of the stock and scion on bud growth.

Container grown prinsepia grows best at relatively low media pH and with a high level of nitrogen. pH values rose dramatically, probably due to high pH of the water used for irrigation. Since media pH was not regulated after initial adjustment, further work will be required to establish pH values as well as levels of other macro and micronutrients.

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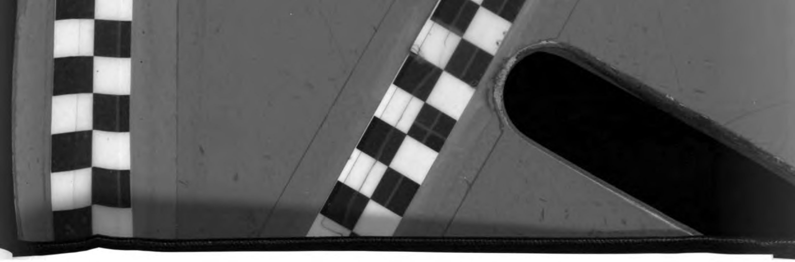

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