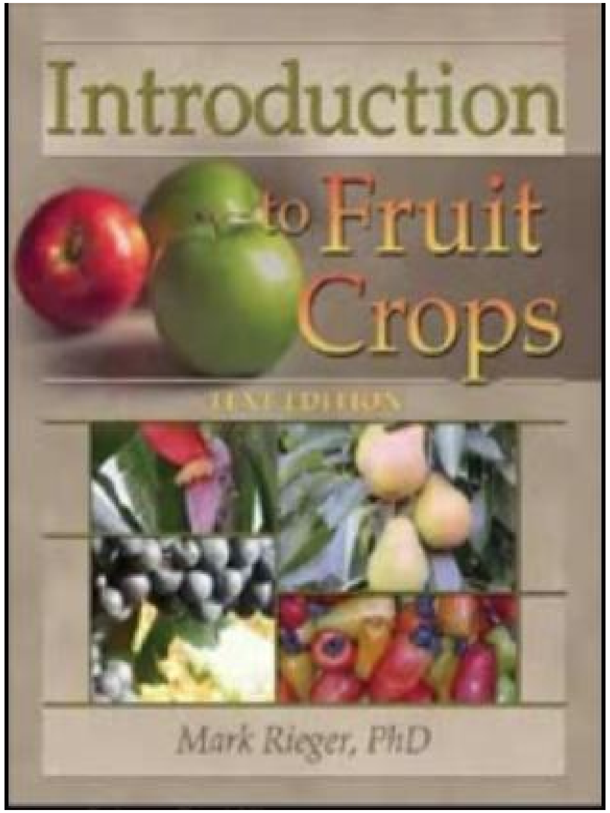
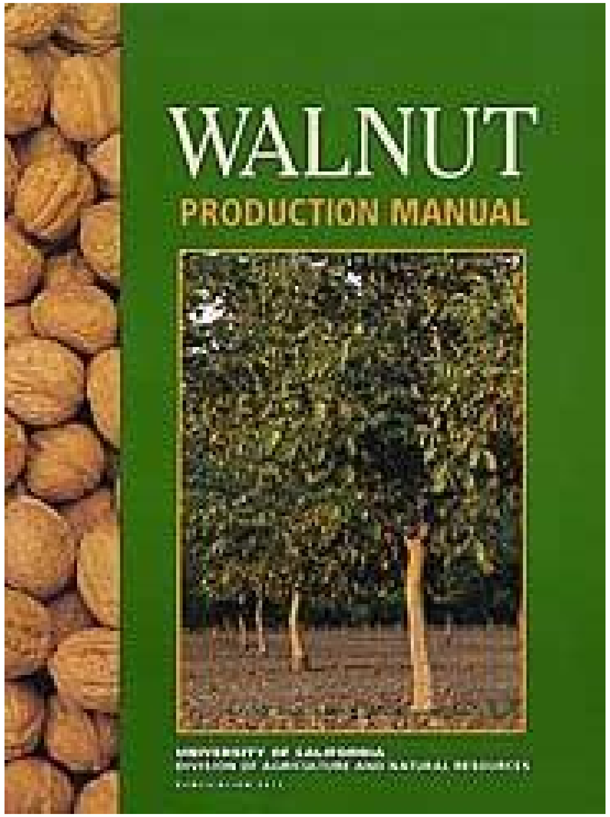
In the Name of God

Nuts


Introduction
to Fruit
Crops
Mark Rieger, PhD


WALNUT
PRODUCTION MANUAL
UNIVERSITY OF CALIFORNIA
DIVISION OF AGRICULTURE AND NATURAL RESOURCES


CRC
Handbook
of
Fruit Set
and
Development

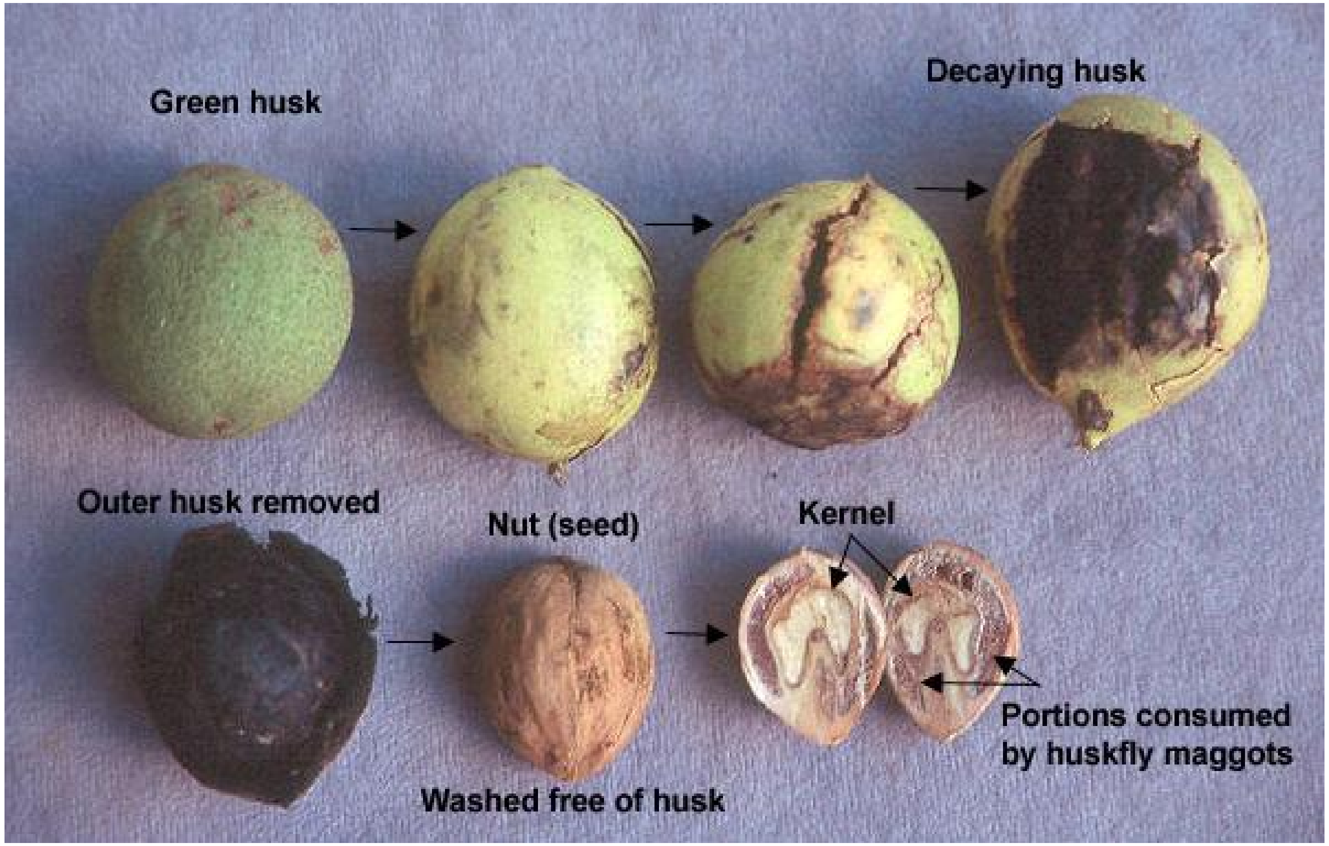





J. nigra






Green husk
Decaying husk
Outer husk removed
Nut (seed)
Kernel
Portions consumed
by huskfly maggots
Washed free of husk


J. californica


J. microcarpa


J. hindsii

J. major



Photo © Kevin Goodson


© Copyright GardenGrapevine.com

J. cinera


Juglans nigra
(C) 2002, Gary Fewless
Juglans cinerea

J. ailantifolia

J. cathayensis

J. mandshurica

- Origin
- According to Roman legend, the walnut originated when Bacchus, the Roman god of pleasure, fell in love with Carya, the youngest of three daughters of Dion, king of Laconia. When the jealous older sister endeavoured to prevent the two from meeting, Bacchus turned them into stones and, for reasons clear only to a Roman god, transformed his beloved into a walnut tree. In recent times, most observers have suggested the crop has more mundane origins.

Fruit characteristics of 70 walnut genotypes grown in Markazi Province during the 2007-2008

Trait	Mean± SD	Min.	Max.	Variation range
Nut length (mm)	34.59±3.13	27.94	42.20	14.26
Nut thickness (mm)	31.78±2.37	26.92	37.11	10.19
Nut width (mm)	30.94±2.03	26.62	35.98	9.36
Kernel weight (g)	4.91±1.23	2.69	8.10	5.40
Nut weight (g)	10.31±2.14	6.33	16.89	10.56
Shell thickness (mm)	1.43±0.23	1.03	2.06	1.03
Kernel percentage	49.95±6.14	31.76	60.51	28.75
Oil content (%)	63.62±5.75	51.00	73.06	22.06

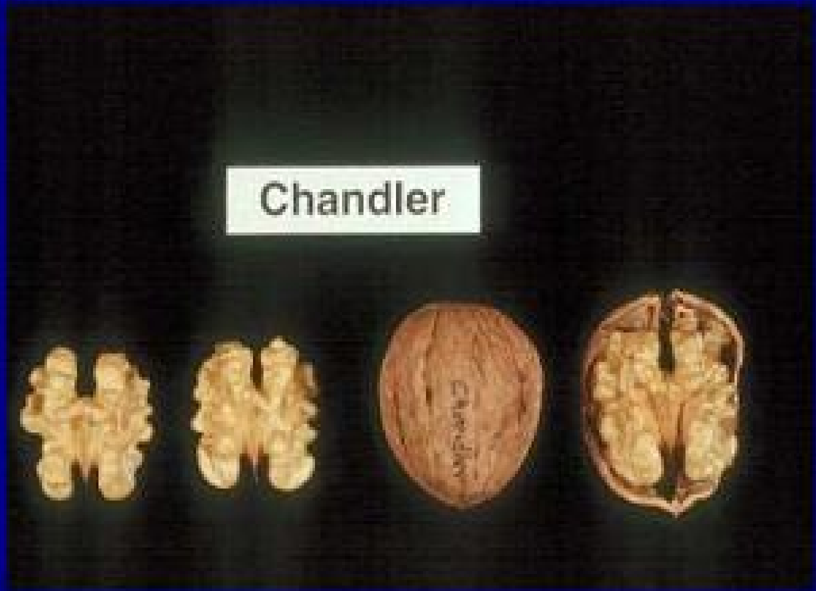
Nut Data Comparison

Trait	Ivanhoe	Serr	Chandler
In shell wt. (g)	13.3 g	14.6	13.4 g
Kernel wt (g)	7.6 g	8.2	6.7 g
Percent kernel	57 %	56.1%	49 %
% Extra light	41 %	7%	53 %
% Light	51 %	70%	41 %

Breeding for New Varieties

Goals:

- Early Harvest date
- High yield
- Light color kernel
- High percent kernel
- Blight resistance
- Low PFA
- Laterally fruitful
- Ease of halves
- Precocity
- Nut size
- In-shell traits



Dietary value, per 100 gram edible portion

	Persian Walnut
Water (%)	3-5
Calories	651
Protein (%)	14.8
Fat (%)	64
Carbohydrates (%)	16
Crude Fiber (%)	2.1
	% of US RDA*
Vitamin A	0.6
Thiamin, B1	24
Riboflavin, B2	8.1
Niacin	5.0
Vitamin C	4.4
Calcium	12
Phosphorus	48
Iron	31
Sodium	—
Potassium	9.6

* Percent of recommended daily allowance set by FDA, assuming a 154 lb male adult, 2700 calories per day.

Top 25 Commodities (2010)

Area	Production (tonnes)	Flag	Production (1000$ Int)	Flag
China	1060600	F	1646714	*
United States of America	457221		709893	*
Iran (Islamic Republic of)	270300	F	419675	*
Turkey	178142		276588	*
Ukraine	87400		135699	*
Mexico	76627		118973	*
India	38000	*	59000	*
Romania	34359		53347	*
France	30460		47293	*
Chile	30000	F	46579	*
Greece	22200		34468	*
Serbia	21419		33256	*
Egypt	20865		32396	*
Uzbekistan	14000	F	21737	*
Spain	13600		21116	*
Belarus	13500	F	20960	*
Italy	13200	F	20495	*
Germany	12200	F	18942	*
Afghanistan	11900		18476	*
Republic of Moldova	11583		17984	*
Pakistan	10838		16827	*
Morocco	10682		16585	*
Czech Republic	10100	F	15682	*
Argentina	10000	F	15526	*
Poland	9600		14905	*

Top 25 Commodities (2005)

Area	Production (tonnes)	Flag	Production (1000$ Int)	Flag
China	499074		774875	*
United States of America	322051		500024	*
Iran (Islamic Republic of)	170000	F	263946	*
Turkey	150000		232894	*
Ukraine	91000		141289	*
Mexico	79871		124010	*
Romania	47810		74231	*
France	32716		50796	*
India	32000	*	49684	*
Egypt	27000	F	41921	*
Greece	21784		33822	*
Serbia and Montenegro	21264		33015	*
Belarus	18937	F	29402	*
Austria	17031		26443	*
Germany	16880	F	26208	*
Italy	16000	F	24842	*
Uzbekistan	16000	F	24842	*
Pakistan	14867		23083	*
Chile	14500		22513	*
Republic of Moldova	13369		20757	*
Georgia	13252		20575	*
Azerbaijan	12529		19453	*
Morocco	10128		15725	*
Argentina	9491	F	14736	*
Spain	8629		13398	*

Top 25 Commodities (2000)

Area	Production (tonnes)	Flag	Production (1000$ Int)	Flag
China	309875		481120	*
United States of America	216820		336640	*
Iran (Islamic Republic of)	130605		202781	*
Turkey	116000		180105	*
Mexico	60000	F	93158	*
Ukraine	49995		77623	*
Romania	31503		48912	*
India	31000	*	48131	*
France	28615		44428	*
Serbia and Montenegro	23776		36915	*
Greece	23518		36515	*
Egypt	20440		31736	*
Pakistan	18398		28565	*
Germany	18200		28258	*
Austria	17082		26522	*
Italy	16000	*	24842	*
Georgia	15492		24053	*
Belarus	13655	F	21201	*
Russian Federation	12000	F	18632	*
Spain	11418		17728	*
Chile	11340		17607	*
Azerbaijan	9983		15500	*
Argentina	9338	F	14498	*
Uzbekistan	9000	F	13974	*
Hungary	7847		12183	*

سطح زیرکشت، میزان تولید و عملکرد محصولات باغی (دایمی) کشور
به تفکیک محصول در سال ۱۳۸۷

جدول شماره ۲-۱ ((واحد: هکتار))

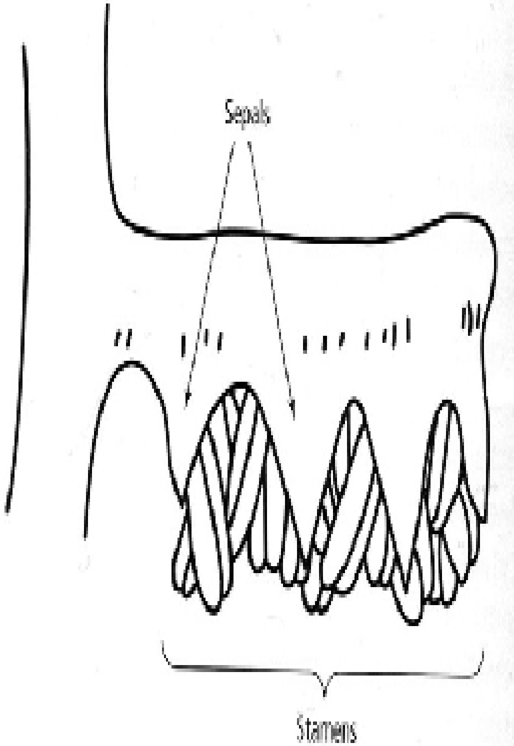
نام محصول	سطح بارور			سطح غیربارور			جمع سطح بارور و غیربارور		
	آبی	دیم	جمع	آبی	دیم	جمع	آبی	دیم	جمع
پسته	۳۷۹۱۷٦,۷	۲۱,۳	۳۷۹۱۹۸	٥۱۸۹٦,۱	٥٥,۹	٥۱۹٥۲	٤۳۱۰۷۲,۸	۷۷,۳	٤۳۱۱٥۰
بادام	۸۹۰٥۱,۱	٥۷٦۱۰,۷	۱٤٦٦٦۱,۸	۲۱٦٥۱,۳	۱٦۹۸۱,٦	۳۸٦۳۲,۹	۱۱۰۷۰۲,٥	۷٤٥۹۲,۳	۱۸٥۲۹٤,۷
گردو	۱٥۰٥۱۲,۳	٥۲٥۲,٤	۱٥٥۷٦٤,۷	٥٤۳۹۳,٥	۳٥۱۱,٦	٥۷۹۰٥	۲۰٤۹۰٥,۸	۸۷٦۳,۹	۲۱۳٦٦۹,۷
فندق	۱۳۰٥۸,٤	۹۷۸۸,۹	۲۲۸٤۷,۳	۱٤۷۸,۸	۸٦٦	۲۳٤٤,۸	۱٤٥۳۷,۲	۱۰٦٥٤,۹	۲٥۱۹۲,۱

سطح زیرکشت، میزان تولید و عملکرد محصولات باغی (دایمی) کشور
به تفکیک محصول در سال ۱۳۸۷

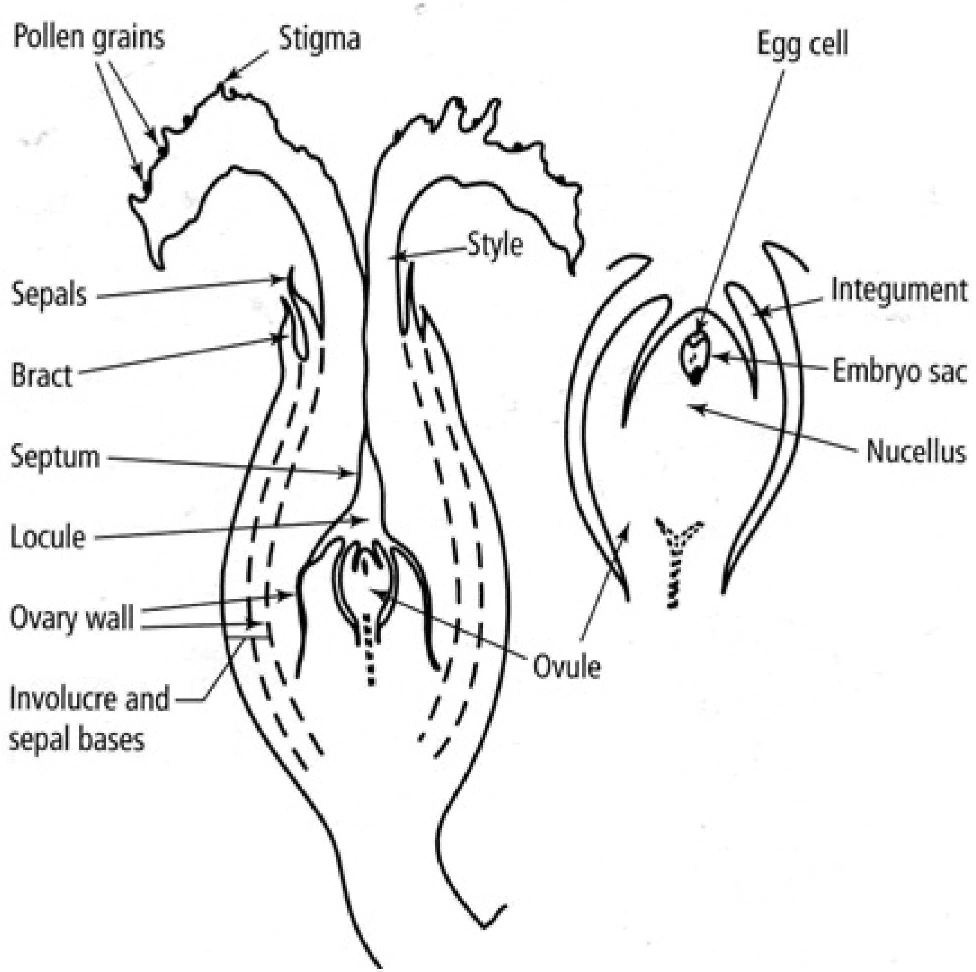
ادامه جدول شماره ۲-۱ ((واحد: تن - کیلوگرم))

نام محصول	تولید			عملکرد	
	آبی	دیم	جمع	آبی	دیم
پسته	۱۹۲۲۶۶	۳	۱۹۲۲۶۹	۵۰۷,۱	۱۵۸,۹
بادام	۱۰۲۸۸۲	۲۳۷۹۷	۱۲۶۶۷۹	۱۱۵۵,۳	۴۱۳,۱
گردو	۳۶۲۱۴۳	۱۷۰۲۷	۳۷۹۱۷۱	۲۴۰۶,۱	۳۲۴۱,۹
فندق	۱۸۶۰۷	۱۱۶۳۶	۳۰۲۴۳	۱۴۲۴,۹	۱۱۸۸,۷

Franquette	5	late	5.3	47	90	good	fair
Treve Mayette		late	-	-	78	poor	low
Eureka		late	7.7	50	40	good	moderate
Payne	88	early	5.7	50	68	good	high
Hartley	5	late	6.1	46	76	good	high
Serr	85	mid	5.8	50	70	good	low
Ashley	85	early	5.8	50	70	adequate	high
Sunland	82	mid	10.6	57	85	good	high
Chico	96	very early	5.2	47	60	good	very high
Vina	70	mid	6.3	49	90	good	high
Amigo	74	early	5.9	51	63	fair	high
Howard	89	late	6.6	49	96	good	very high
Chandler	89	late	6.5	49	100	adequate	very high
Tulare	72	mid/late	7.5	53	86	good	high
Lompoc	50	early	7.5	54	60	good	high


Sepals
Stamens


www.ImagesFromBulgaria.com


Pollen grains
Stigma
Egg cell
Style
Sepals
Integument
Bract
Embryo sac
Nucellus
Septum
Locule
Ovary wall
Ovule
Involucre and sepal bases

“incomplete” flowers – unisexual and sepals and petals lacking

black walnut *Juglans nigra* (Juglandaceae)

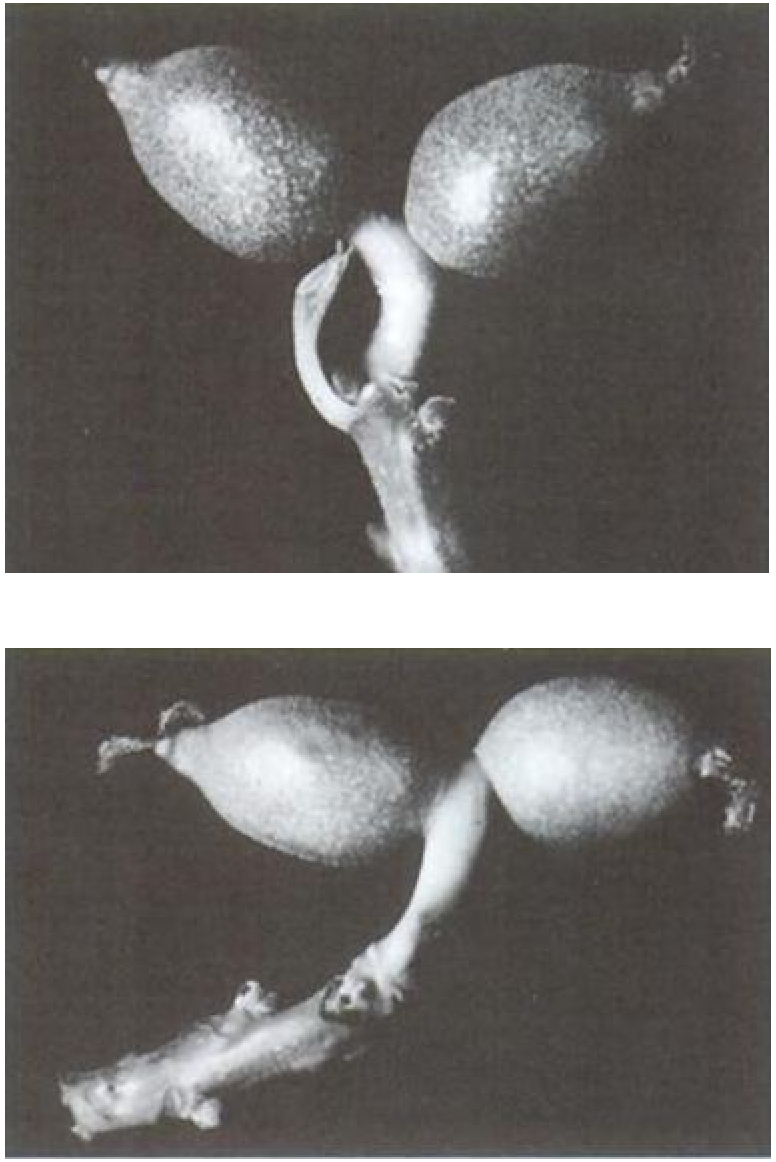



Figure 16.9 These pictures show pollinated (above) and unpollinated (below) fruitlets 3 weeks after the peak of the receptive period. Note the differences in the general appearance of the stigmas. Also note that, although they are incapable of setting fruit, the unpollinated flowers have grown to approximately the same size as the pollinated flowers. Eventually, however, unpollinated flowers drop from the tree.

ISHS Acta Horticulturae 442: III International Walnut Congress 1995

PISTILLATE FLOWER ABSCISSION ON FOUR WALNUT CULTIVARS

Authors: M. ROVIRA, N. ALETÀ

Abstract:

The effect of pollen on pistillate flower abscission (PFA) was studied in four cultivars of *J. regia* L.: two from California ('Serr' and 'Hartley'), one from Chile ('AS-1') and one Spanish selection ('MB-T-119'). Self-pollen and pollen of pollinators were applied to pistillate flowers. Natural pollinated flowers were used as reference. The experiment was carried out during Spring of 1994 in the germplasm collection of IRTA at Mas Bové.

Results showed that PFA in these four cultivars was significantly different. 'AS-1' was the least affected with a PFA ratio of 2% and 'MB-T-119' had the highest proportion of PFA near 80%. In 'Hartley' and 'Serr' PFA percentage was about 50%. This relation between PFA and cultivar was also detected under natural pollination conditions.

The artificial load of pollen applied to female flowers increased significantly the percentage of PFA comparing to reference flowers (from 25% for references to 55% for artificial pollinated on average). However, 'AS-1' had in both cases the same low level of PFA.

Fruit set was also affected by the amount of pollen. A high negative correlation (>0.9) between PFA and fruit set was found.

Pollination of English Walnuts: Practices and Problems

« Previous | Next Article »
Table of Contents

This Article

HortTechnology **January–March 2000** vol. 10 no. 1 **127–130**

William H. Krueger

English walnut (*Juglans regia, L.*) is a monoecious species bearing staminate and pistillate flowers separately on the same tree. Walnuts are generally self-fruitful, cross-compatible and dichogamous, having incomplete overlap of pollen shed and female receptivity. It is this characteristic which led to the recommendation that about 10% of the trees in a commercial planting be a cultivar with a pollen shed period overlapping pistillate flower receptivity of the main cultivar. Excessive pollen load has been implicated in the `Serr' cultivar in pistillate flower abortion (PFA), the loss of the female flowers early in the season before fruit drop due to lack of pollination. PFA can be reduced and yield improved in `Serr' orchards by reducing pollen load. This can be accomplished by pollinizer removal, or catkin removal at the beginning of pollen shed by mechanical shaking. In years of significant bloom overlap between staminate and pistillate bloom, PFA can be further reduced and yield improved by removing `Serr' catkins. PFA occurs to a lesser extent in other cultivars such as `Chico', `Chandler', `Vina' and `Howard'. This information has led to the reevaluation of pollinizer recommendations. Research focused on optimum pollinizer levels in `Chandler', a cultivar of increasing importance to the California walnut industry, has been inconclusive. Lack of pollinizers may impact yields to a greater extent in the in the northern San Joaquin Valley and Sacramento Valley than in the southern San Joaquin Valley. In any case the previously recommended 10% appears to be excessive. Two to three percent is probably adequate to limit losses due to lack of pollination without resulting in excessive PFA, and is currently being recommended by extension farm advisors and specialists. Factors to consider when determining the number of pollinators to plant include: cultivar susceptibility to PFA, walnut pollen load in the area and local pollination and fruit set experiences.

EFFECT OF RETAIN® IN REDUCING PISTILLATE FLOWER ABORTION IN SERR WALNUT

Robert H. Beede[1]

PFA is the loss of nut-producing pistillate flowers early in the season, typically 2 to 3 weeks after bloom. This was first noted in the Serr cultivar soon after the earliest plantings came into production in the early 1970's. Originally referred to as the Serr drop problem, flower loss due to this phenomena sometimes exceeded 90 percent in certain orchards and years. Determining the cause of the disorder proved extremely difficult. By the late 1980's the above researchers had eliminated mites, walnut blight, numerous nutritional deficiencies including nitrogen, calcium, and boron, tree age, shading, pruning practices, water stress, intratree competition for nutrients, incompatible pollen and lack of pollination. Cherry Leafroll virus, the cause of Blackline, was also studied as a possible cause and eliminated (Polito et al.).

Research by Dr. Polito (unpublished) showed that the excessive pollen tubes growing down the style of the female walnut flower produce excessive amounts of ethylene, a natural plant hormone associated with organ senescence. Elevated ethylene levels are likely the cause of flower abortion. Polito also field tested non-commercial compounds which either promoted or inhibited ethylene production and observed corresponding increases and reductions in PFA.

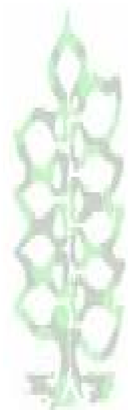
Recently, Retain®, a commercially available ethylene inhibitor developed by Valent BioSciences, has been widely tested on stone fruit for improving post harvest shelf life. This season, a simple test of its effect on Serr PFA was conducted in Kings County. A nine-year old block of Serr walnuts south of a Chandler orchard was selected. Ten fruiting shoots in each of twenty trees 120 to 150 feet south of the Chandler orchard were then tagged. The selected shoots each had two female walnut flowers in an early stage of pollen receptivity. Five of the shoots on each tree were treated with the equivalent of 11.7 ounces per acre of Retain®. The other five shoots per tree were left untreated. On May 5, 2003, the number of fruit set per shoot were recorded and analyzed as a randomized complete block. The shoots within each tree were treated as subsamples and the trees were evaluated as replications. Visual and statistical results showed a consistent improvement in fruit set from the Retain® application. Overall, Retain® treatment resulted in 89.0 percent set of the potential 200 flowers. Only 21.5 percent set was recorded in the untreated shoots. This was highly significant statistically.

THIRTIETH ANNUAL MEETING

PLANT GROWTH REGULATION SOCIETY OF AMERICA

HELD JOINTLY WITH

THE JAPANESE SOCIETY FOR CHEMICAL REGULATION OF PLANTS



VANCOUVER AIRPORT CONFERENCE RESORT
VANCOUVER, BRITISH COLUMBIA, CANADA

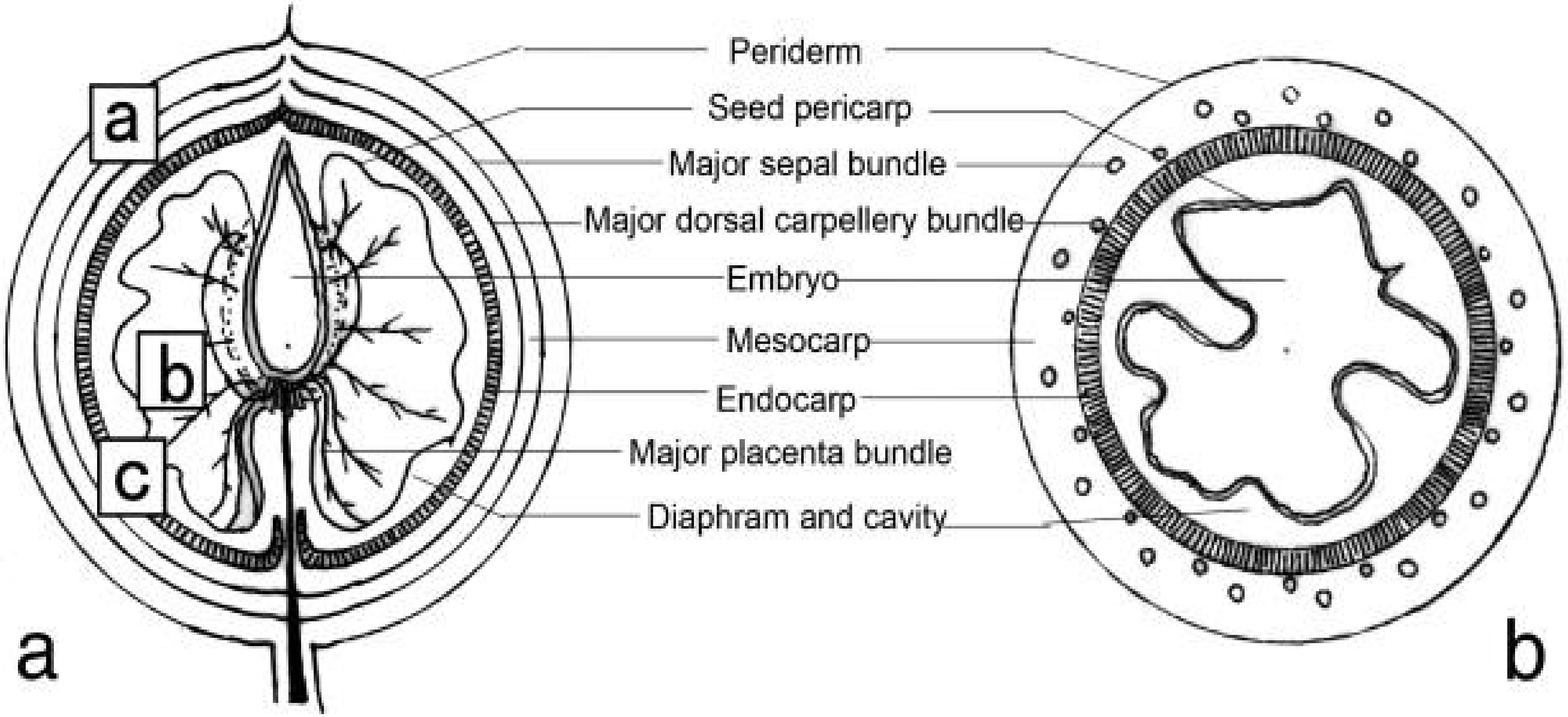
AUGUST 3 – 6, 2003

Control of pistillate flower abortion in 'Serr' walnuts in Chile by inhibiting ethylene biosynthesis with AVG

Lemus, G.[1], González, C.[1] and Retamales, J.[2, 3*]

A. Ramina et al. (eds.), Advances in Plant Ethylene Research: Proceedings of the 7th International Symposium on the Plant Hormone Ethylene, 305–307.

1000 or 2000 liters per hectare. Fruit set that season averaged 25% in the untreated controls. Application of AVG at 125 and 250 mg/l increased fruit set up to 80%, with AVG applied at 125 mg/l (i.e. 125 ppm of AVG) and with a spray coverage of 1000 liters per hectare being rated as the most appropriate treatment. During 2005/2006 season, AVG applications using 125 ppm of AVG were performed in several orchards. Natural fruit set in the untreated controls ranged from 35 to 83%. Despite less incidence of PFA in the latter season as compared with the previous one, in most of the orchards AVG application led to increased fruit set, particularly when PFA was high, resulting, thus, in significant improvements in yield potential in such cases. These results are indicating that AVG can be a powerful tool to overcome PFA and subsequent yield losses in 'Serr' walnut orchards under Chilean Central Valley conditions.



Pericarp –
- epicarp
- mesocarp
- endocarp

Seed pericarp –
- exotesta(episperm)
- mestotesta(mesosperm;sarcoderm)
- endotesta

Table 18.1 Approximate time of important stages in walnut fruit development.

Weeks after bloom	State of development
1	Fertilization of egg cell.
2	Embryo consists of 2–8 cells. Copious endosperm present.
3	Embryo consists of 8–32 cells.
5	Embryo is globular and consists of up to several hundred cells.
6	Cotyledons begin to grow. Tip hardening begins in shell.
8	Total growth starts to slow relative to rapid, early stage.
9	Kernel begins rapid growth as cotyledons start to fill locule.
10	Final nut size attained.
12–15	Shell sclerification completed.
15	Kernel growth (weight) resumes at a rapid pace.
18	Maximum total weight.
19–22	Approximate date of harvest.

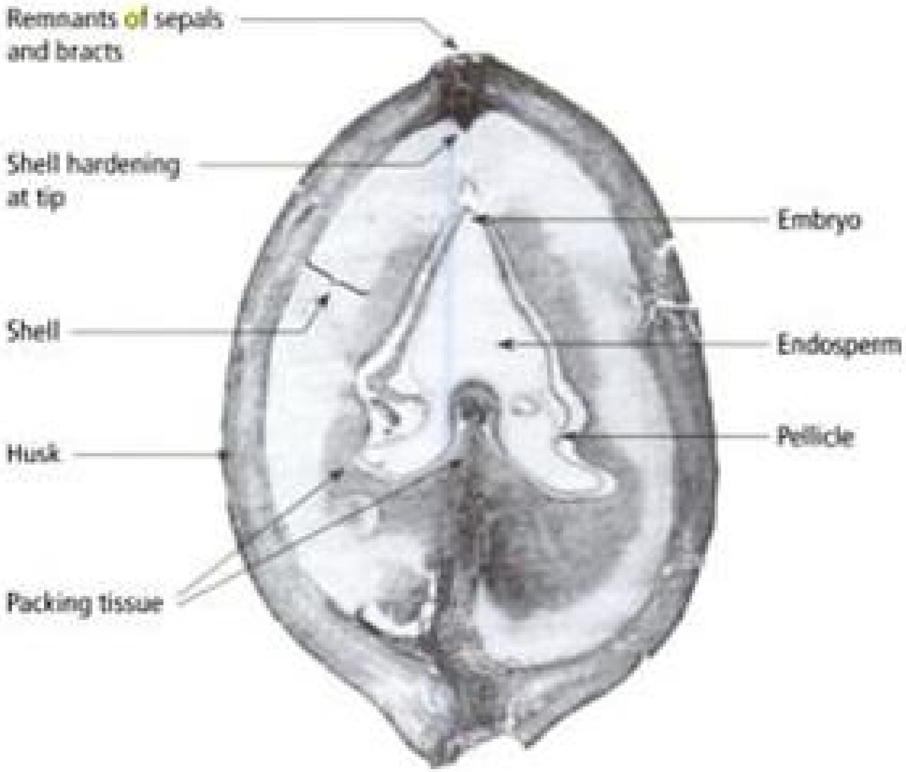
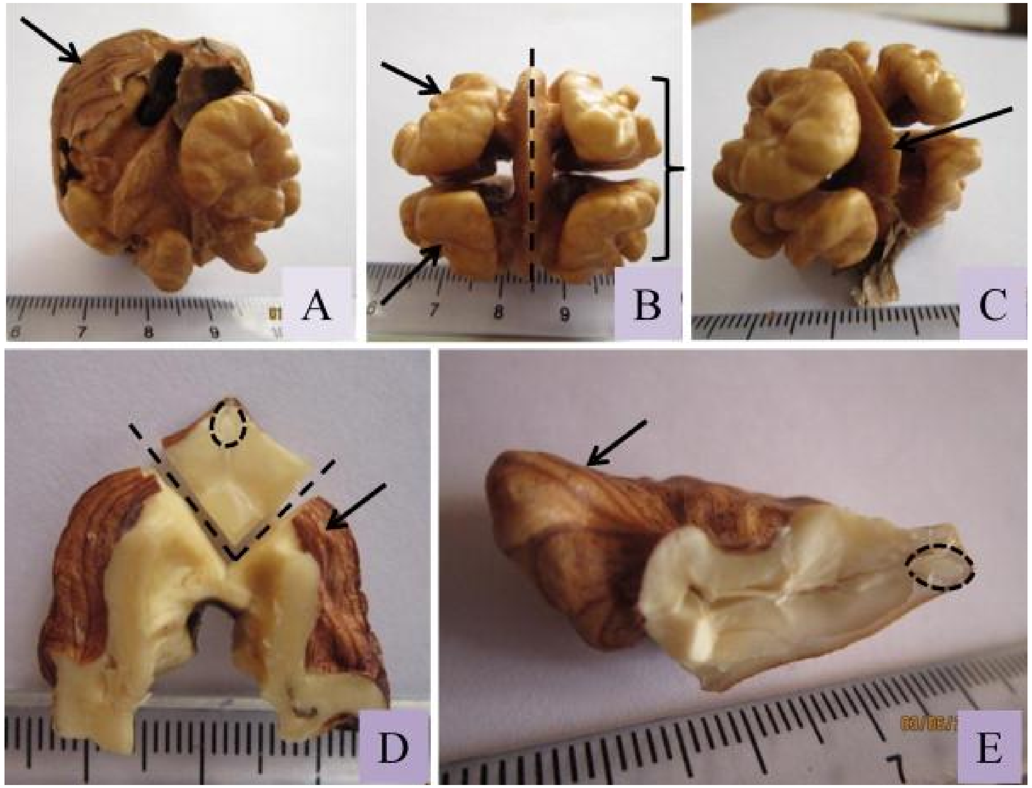


Figure 18.1 A section of a Hartley fruit 5 weeks after pollination. Note the relatively massive endosperm filling the locule and the minute embryo at the apical end of the locule. Note, too, that shell lignification has begun, as indicated by the dense cluster of stained cells at the tip of the shell region.



The structure of walnut kernels. Part of the stony endocarp *i.e.* shell (arrow) has been removed to show the enclosed seed with a wrinkled surface (A). Whole seed axial view showing cotyledons (crochet) each consisting of two cotyledonary lobes (arrows) connected to each other at their ventral surfaces (straight dashed line) through the apparent embryonic axis (B). Tip of the embryonic axis (arrow) in a partly tilted seed in axial view (C). Cotyledonary lobes were excised to show the apparent seed embryonic axis (above the perpendicular dashed lines), true embryonic axis (encircled by the curved dashed lines) and the connecting tissues (arrow) of the axis to cotyledons (D). A single cotyledonary lobe (arrow) and the attached true embryonic axis (encircled by curved dashed lines) in sagittal section with a distal cotyledonary lobe (E). The smallest scale division is equal to 1 mm.

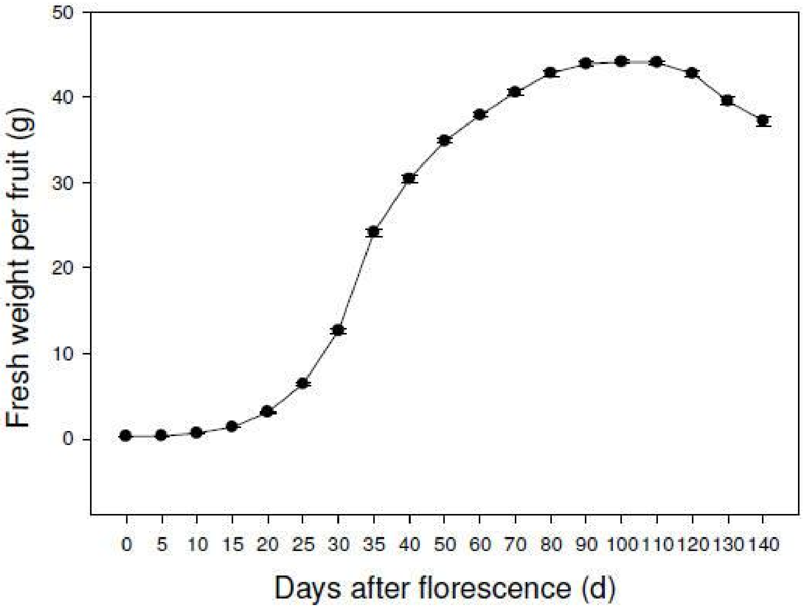


Figure 1. The fruit growth curve of walnut. Error bars indicate standard deviation, n=10.

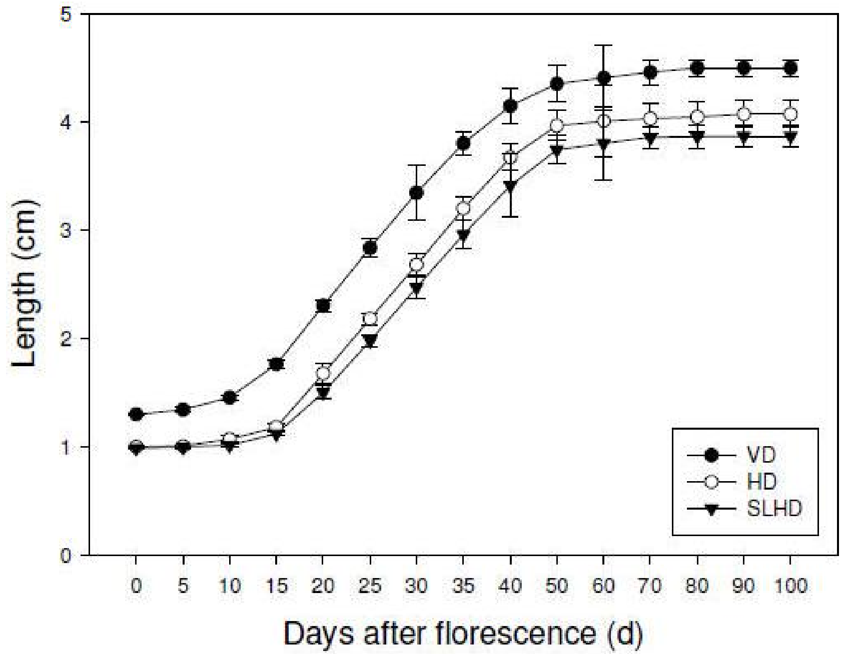
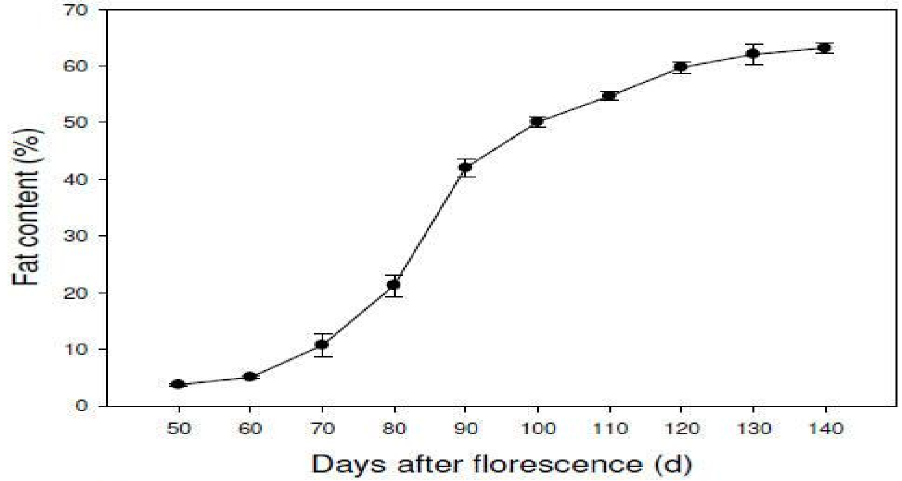


Figure 3. The dynamics of vertical diameter, horizontal diameter and horizontal diameter of suture line per fruit during fruit development.VD: vertical diameter; HD: horizontal diameter; SLHD: horizontal diameter of suture line; Error bars indicate standard deviation, n=10.



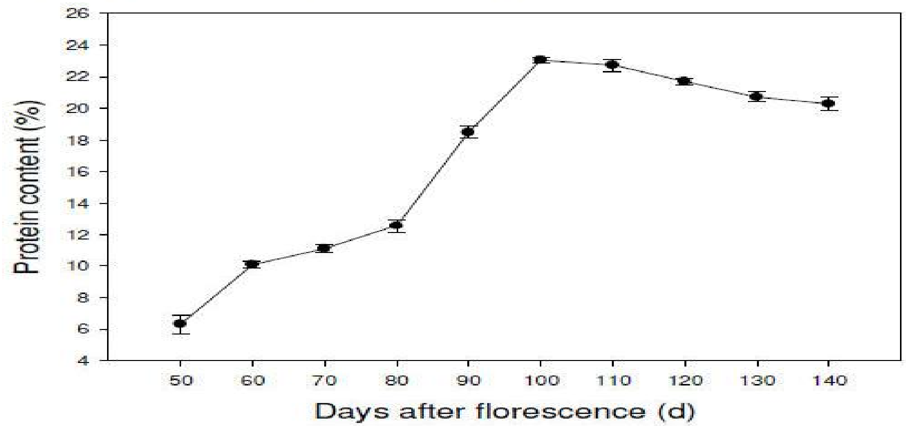


Figure 7. The dynamics of protein content during embryo development. Error bars indicate standard deviation, n=10.

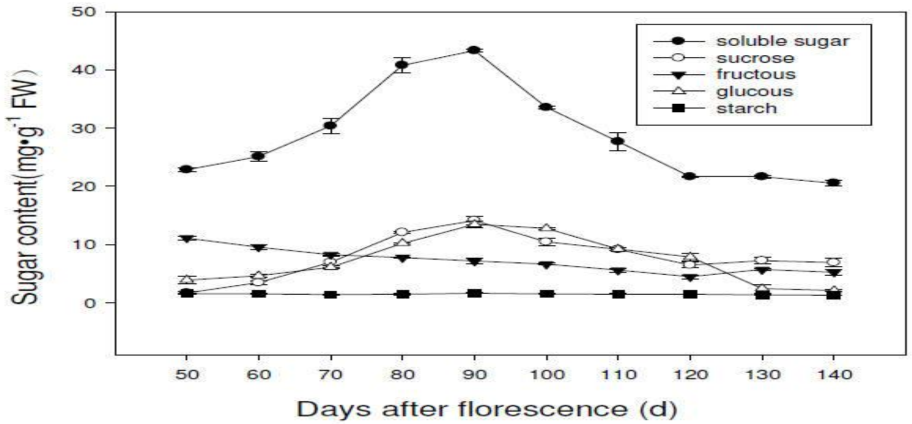


Figure 8. The dynamics of sugar content during embryo development. Error bars indicate standard deviation, n=10.

Improved Success of Persian Walnut Grafting Under Environmentally Controlled Conditions

Aziz Ebrahimi
Kourosh Vahdati
Esmaeil Fallahi

ABSTRACT. Different budding methods (patch, shield and chip) were compared under controlled and field conditions using different native varieties of Persian walnut (*Juglans rejia* L.) during June 2005, in Nieriz, Fars province, Iran. Controlling temperature and humidity in a greenhouse improved grafting success considerably in all grafting methods compared with results under field conditions. The highest success rate was obtained with patch (91.0%) followed by shield (31.1%) and chip (19.1%) budding under greenhouse conditions versus 25.0, 15.0 and 10.0% under field conditions, respectively. Similar trends were also observed for callus formation and scion growth. Patch budding showed the highest callus formation and scion growth followed by shield and chip

Journal of Horticultural Science & Biotechnology (2010) **85** (1) 48–52

Bench-grafting of Persian walnut as affected by pre- and post-grafting heating and chilling treatments

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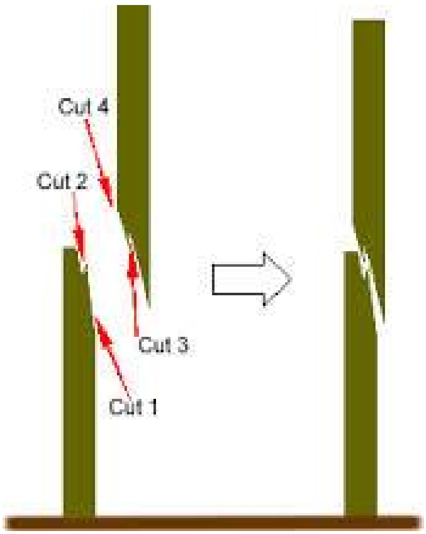
SUMMARY

Walnut grafting is more difficult than in most other fruit trees, and increasing the success of grafting, as well as lowering the cost of grafting, is important for commercial nurseries. Two trials were conducted to find the most efficient procedure for walnut grafting. Each trial was repeated twice during 2006 and 2007. In the first trial, the effects of three bench-grafting methods (i.e., side-stub, omega, and whip-and-tongue) were evaluated on the grafting success of four scion cultivars ('Z_{53}', 'Hartley', 'Pedro', and 'Serr'). Omega grafting gave the highest callus rating (scoring 2.6 out of 4.0), the greatest number of callused plants (82%), the most graft-take (71%), and the highest graft survival rate (81%). In the second trial, the effects of pre-grafting, warm forcing treatments, and chilling of callused plants were studied using the side-stub grafting method and two scion cultivars ('Hartley' and 'Pedro'). Warm forcing (26° – 28°C at 80 – 90% RH) of the scion and rootstock material (for 3 d and 14 d, respectively) along with chilling (2° – 4°C at 80 – 90% RH for 30 d) of callused plants both showed the highest rates of graft-take (78%) and graft survival (84.6%). The lowest level of graft-take (30%) and graft survival (41.6%) occurred in untreated control plants. Our study provides an alternative method for propagating walnut cultivars under partially controlled growth conditions.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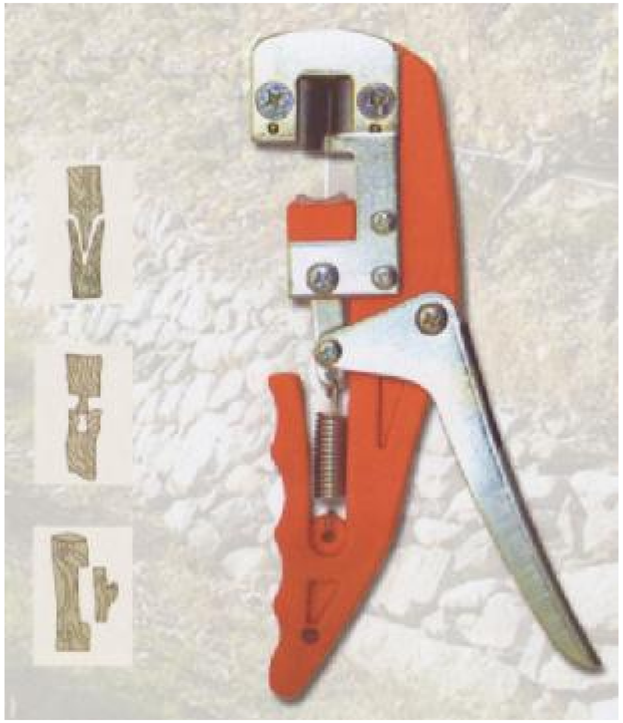

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Introducing a Simple and Efficient Procedure for Topworking Persian Walnut Trees

REZA REZAEE[1] AND KOUROSH VAHDATI[2]

Abstract

To find the most suitable procedure for improving the quality and productivity of Persian walnut trees (*Juglans regia* L.) through topworking, different grafting methods were compared from 2001 to 2006. The effect of cultivar (scion) on grafting success was also assessed in a separate trial with the most successful method of grafting in 2004. Modified bark grafting of scaffolds performed in mid-April resulted in the highest graft take (100%) and survival (> 85%). Grafting success differed (0 to 100%) depending on the cultivar used as the scion. Other grafting (whip and cleft) or budding (chip, patch and I-shaped) methods on scaffolds produced poor results and/or no survival. The number of nuts, color and weight of kernels was superior in the topworked trees compared to the non-topworked ones ($P \leq 0.01$). The modified bark grafting method represents a simple and effective technique to convert inferior walnut trees to desirable cultivars. This technique included delaying grafting date for two weeks after rootstocks were cut back and temporarily covering the graft union with moist sawdust. After about three weeks, the sawdust cover was removed and the graft union was covered with grafting wax.

Figure 1. The modified bark grafting method as done on scaffolds of a 10-year-old walnut *(J. regia)* tree in mid-April, showing dormant scion secured under a bark flap with two nails (left) and covering with moist sawdust (right).

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Walnut grafting success and bleeding rate as affected by different grafting methods and seedling vigour

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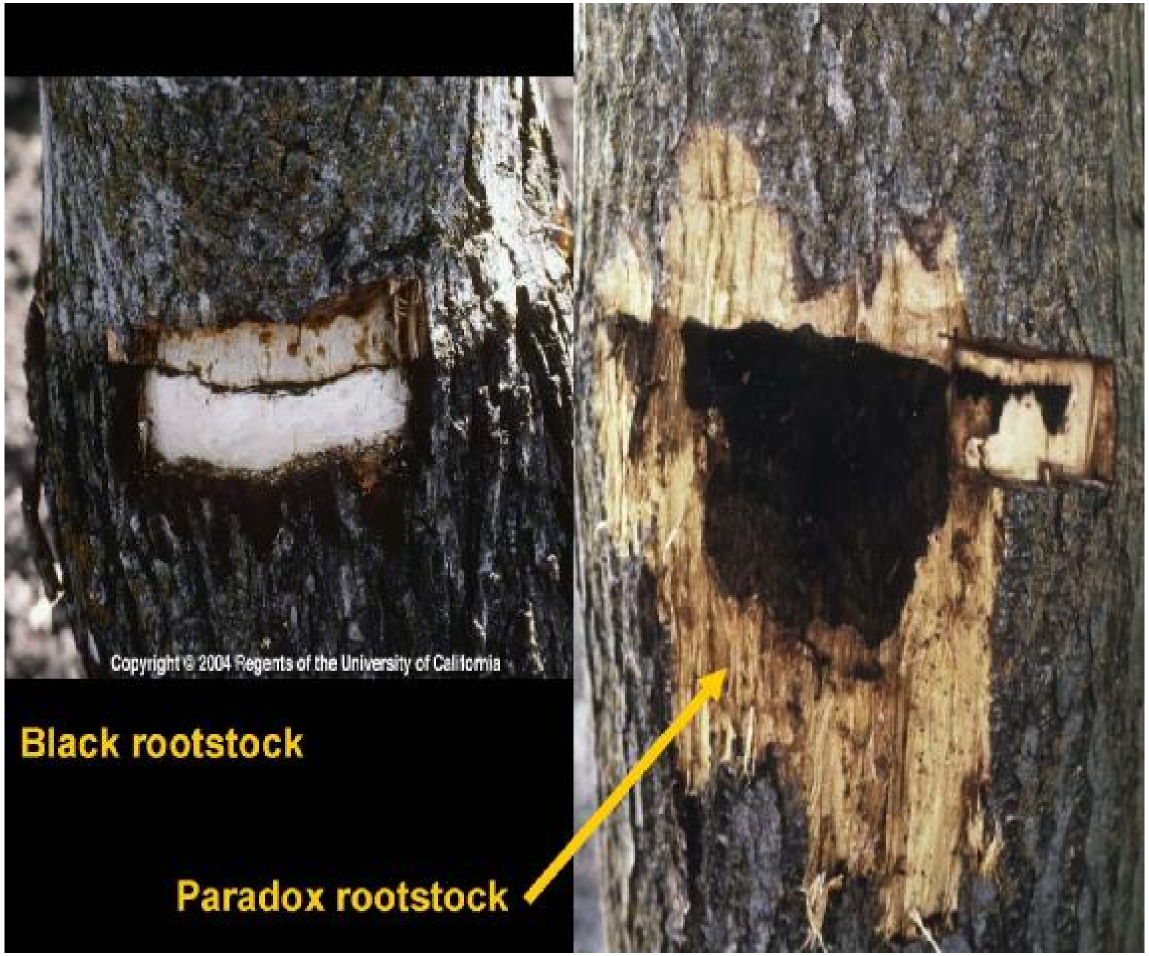
SUMMARY
Different grafting and/or budding methods were compared in terms of grafting success in 2004 and in 2005. Generally, the optimum period of grafting, under our experimental conditions, was limited to the early Spring and late Summer. Modified bark grafting in mid- April was the most convenient and reliable grafting method for 2- to 3-year-old walnut seedlings, with 80 – 93% grafting success. The method consisted of collecting dormant scions in March, cutting the seedling rootstocks back 1 – 2 weeks before grafting in mid-April, and temporarily covering the graft area with moist sawdust for about 3 weeks before waxing. A higher rate of xylem bleeding in early Spring was a major factor in graft failure. Therefore, in the following experiments (2006), the effect of vigour of the different seedlings and methods of bleeding control were investigated for their effects on the bleeding rate, grafting success, and scion growth. Regardless of seedling vigour, temporary covering of the graft area with moist sawdust resulted in the highest grafting success (>80%) mainly by providing suitable conditions required for better callus formation. Scion growth at the end of the growth season (tree height) was significantly less ($P \leq 0.01$) on seedlings of low vigour compared to high-vigour seedlings (62.31 *vs.* 125.20 cm height), underlining their potential importance in the reduction of tree size for high-density planting systems. Xylem bleeding was also reduced in seedlings of low vigour, although this reduction was not significant during the graft healing period.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Black rootstock
Paradox rootstock

John M. Mircetich

Blackline-infected trees on, *above left*, black walnut, and, *above right*, 'Paradox' rootstocks are slowly girdled by the death of rootstock tissue at the graft union. *Top*, over time, walnut trees with blackline decline in vigor, leading to dieback of branches and, ultimately, death of the tree. Trees on English rootstocks develop no graft union symptoms and escape the debilitating effects of blackline infection.


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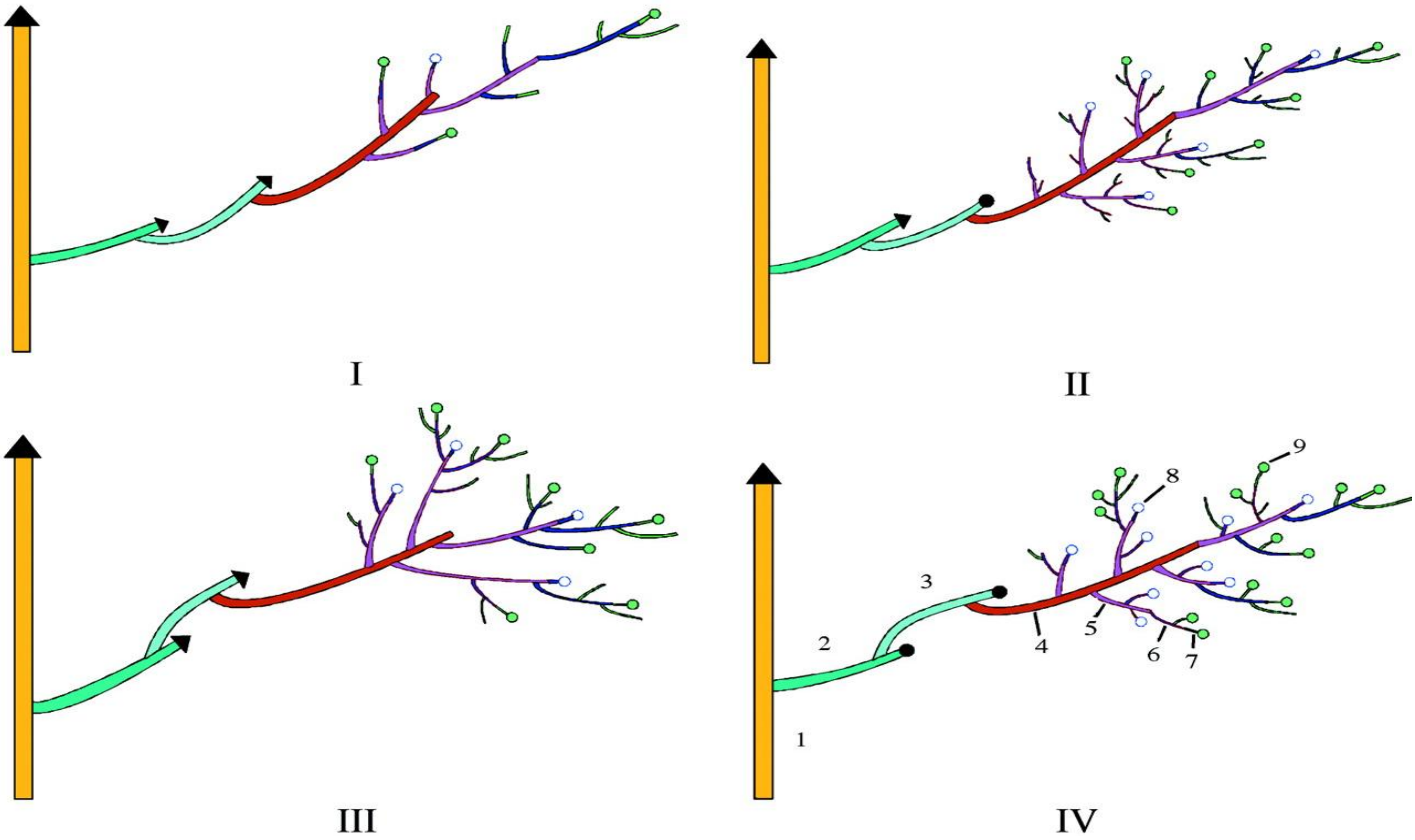
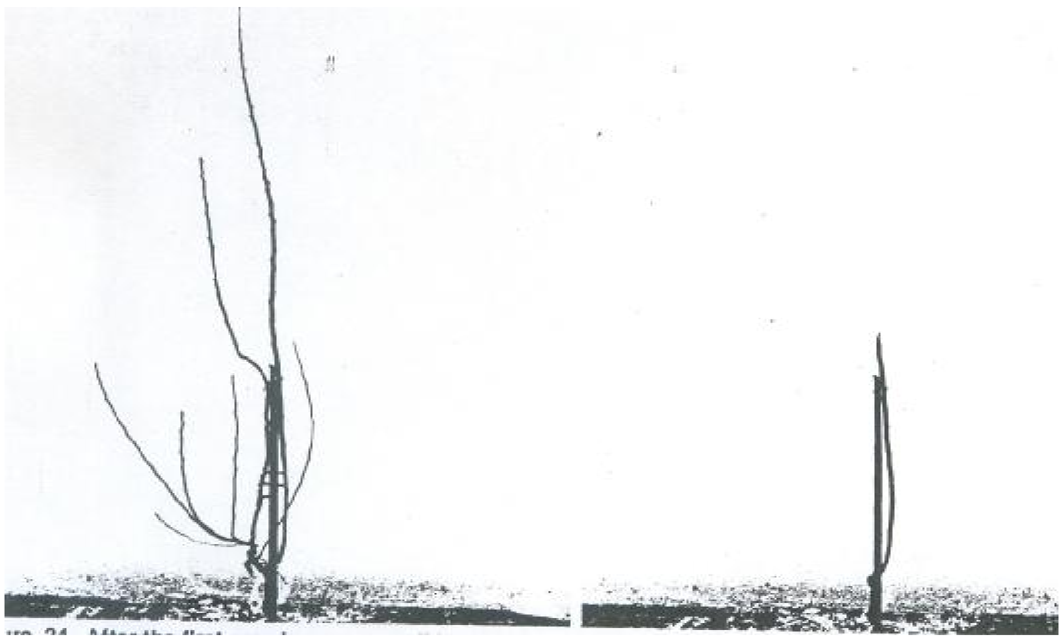
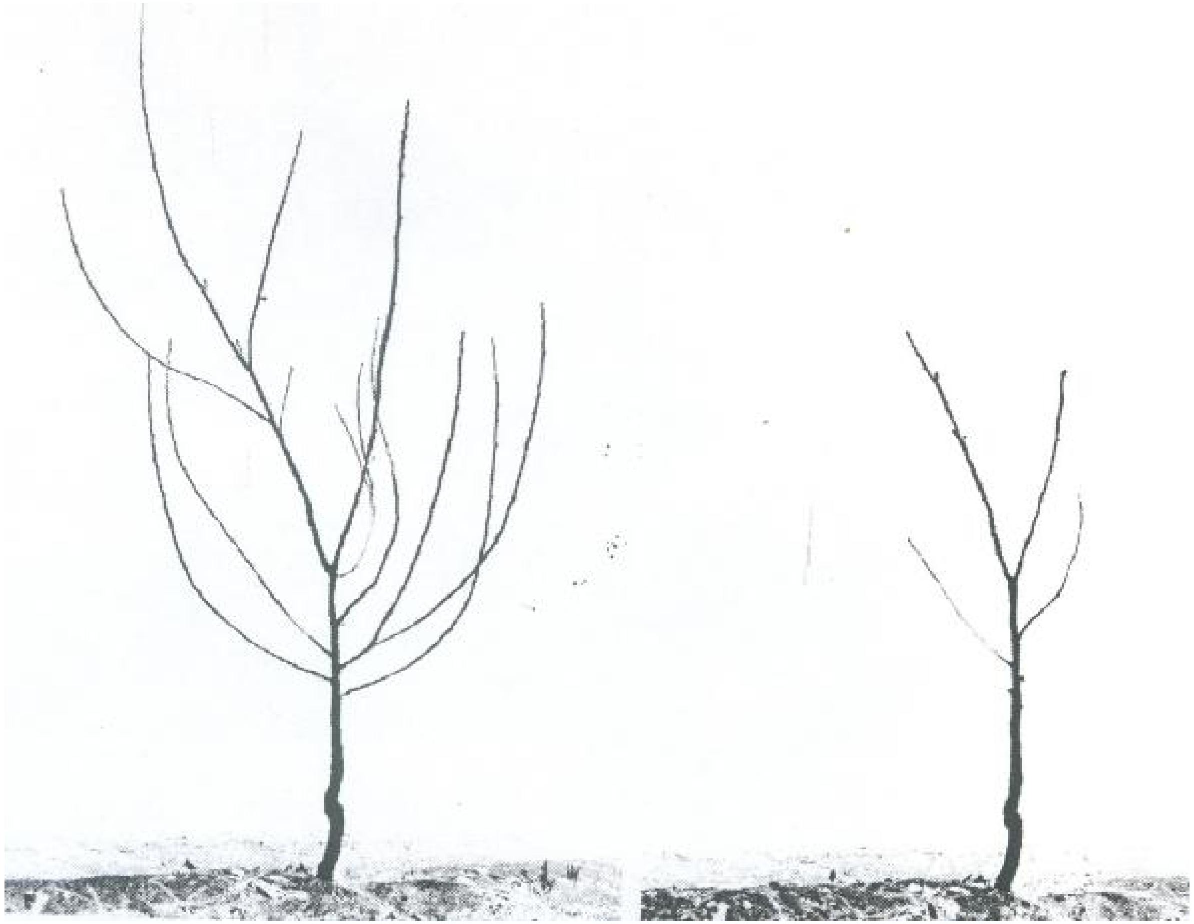
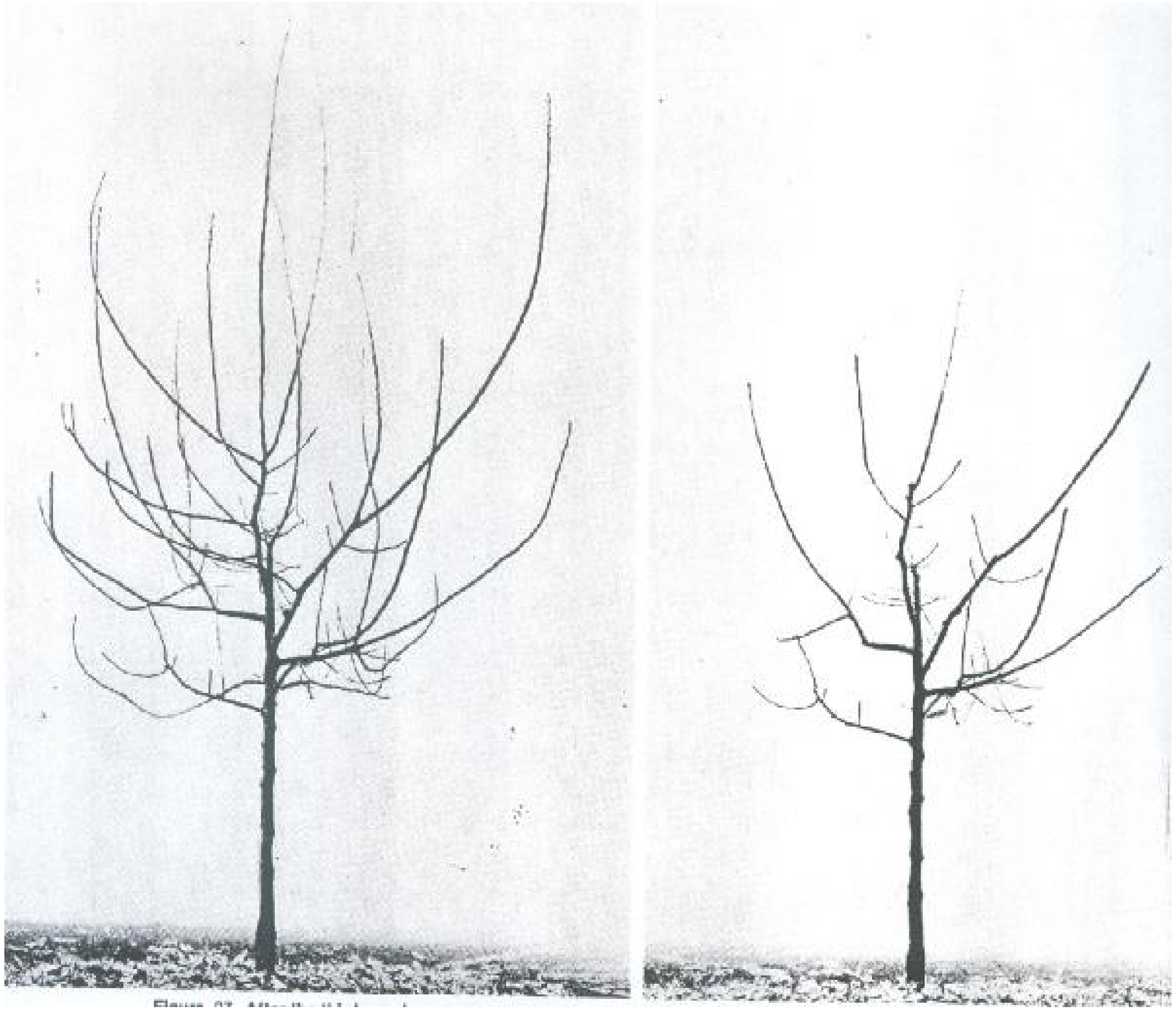
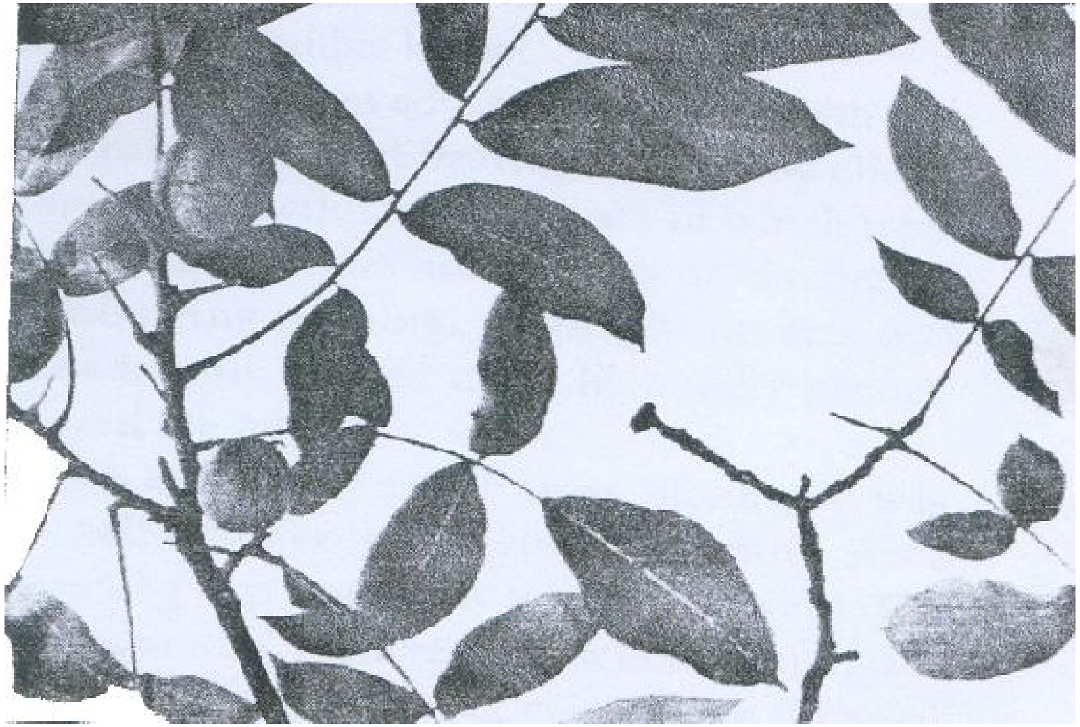


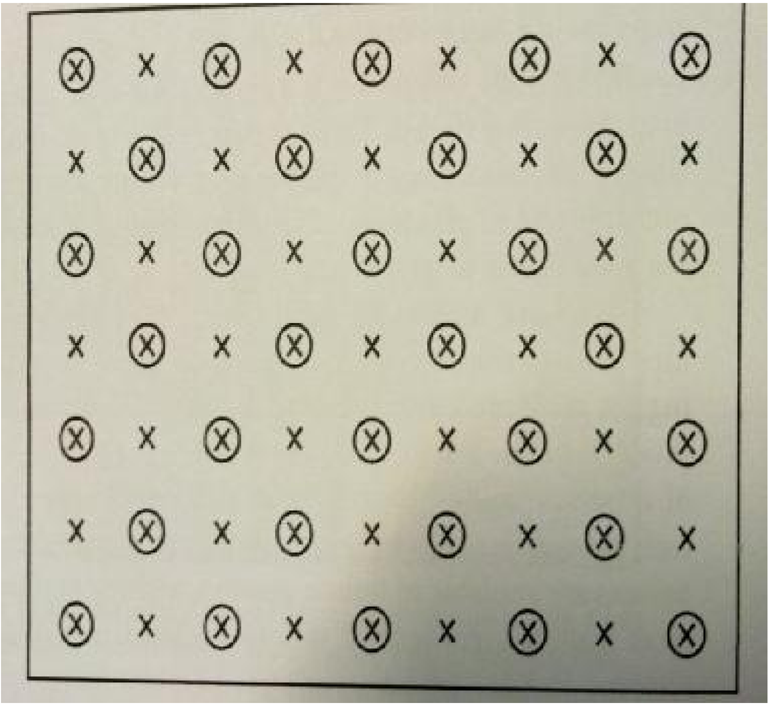
FIG. 2. Architectural unit of walnut morphotypes I (terminal fruit bearing), II (intermediate fruiting with mesotonic branching), III (intermediate fruiting with acrotonic branching) and IV (lateral fruit bearing). 1, Trunk (first order axis) (yellow); 2, primary branch (second order axis) (turquoise); 3, secondary branch (third order axis) (light blue); 4, 3-year-old branch (N-2) (orange); 5, 2-year-old shoot (N-1) (orange); 6, 1-year-old shoot (N) (grey); 7, current season shoot (green); 8, previous year's fruit (white circle); 9, current year's fruit (green circle). Illustration by Mitja Solar.

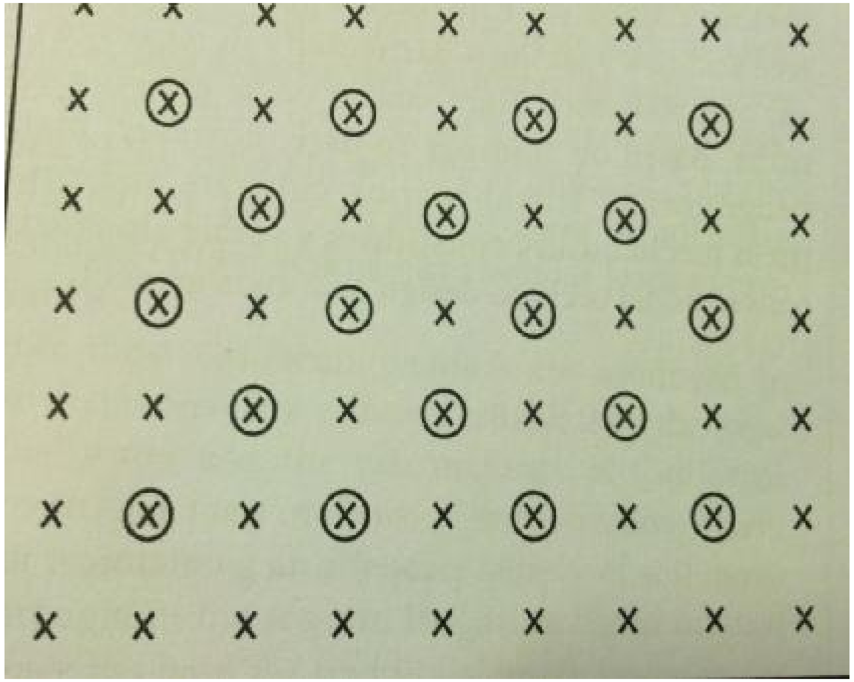


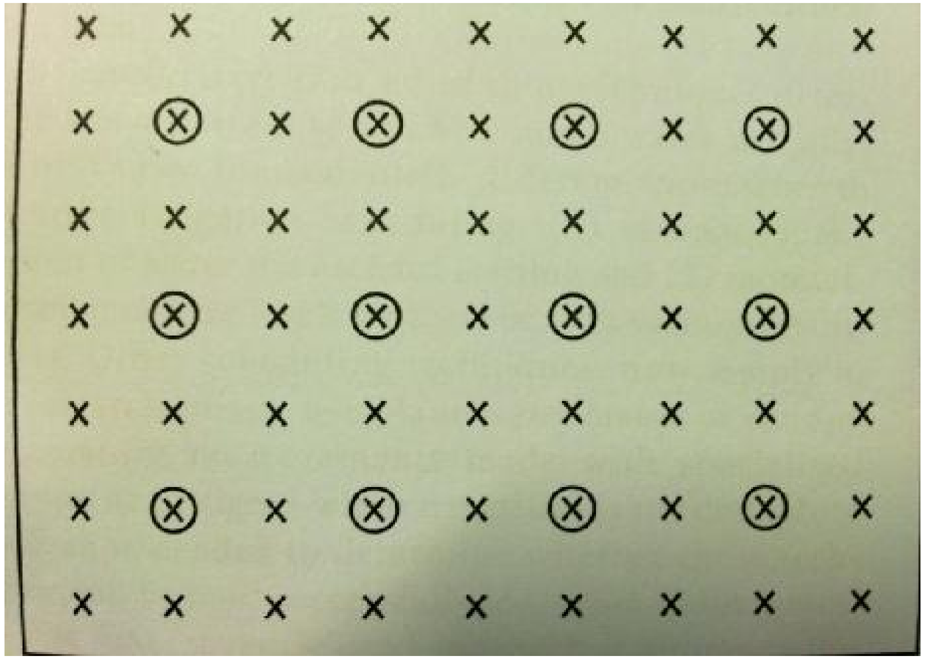


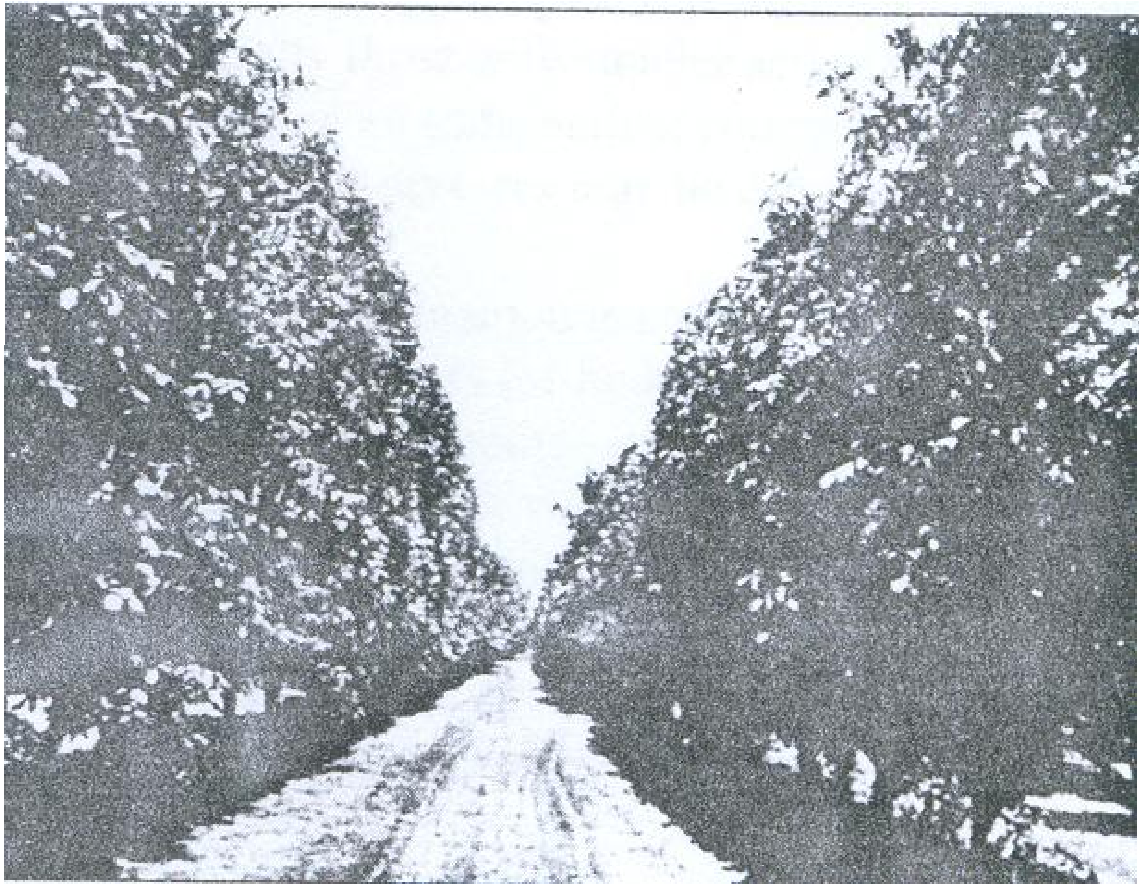


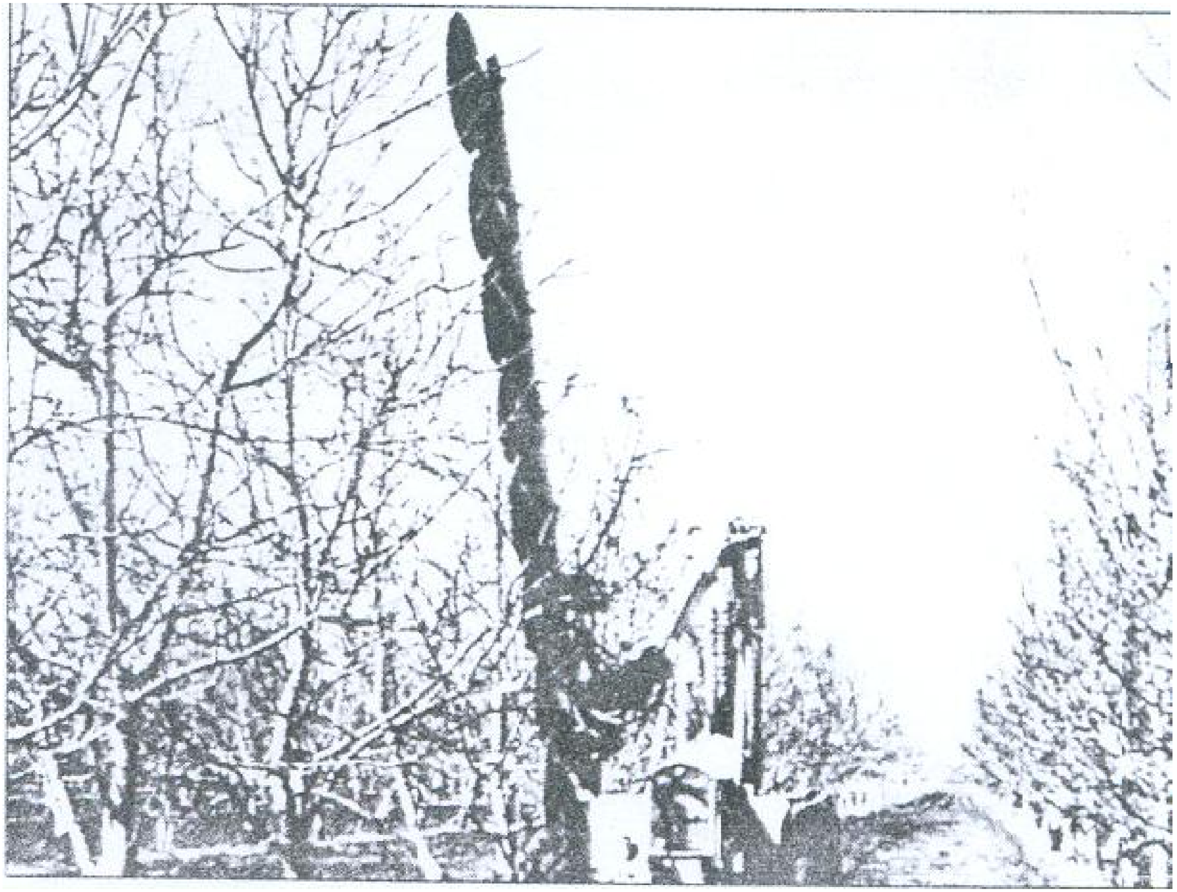












Foliar Application of Zinc and Boron Improves Walnut Vegetative and Reproductive Growth

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ADDITIONAL INDEX WORDS. *Juglans regia*, Zn, B, spray, fruit set, pollen germination, kernel percent

SUMMARY. An experiment was conducted in a persian walnut (*Juglans regia*) orchard in the north of Iran to evaluate the effects of zinc (Zn) as zinc sulfate and/or boron (B) as boric acid in foliar spray with different concentrations and combinations. Three B and three Zn concentrations (0, 174, and 348 $mg \cdot L^{-1}$ for B and 0, 1050, and 1750 $mg \cdot L^{-1}$ for Zn) were applied either independently or in combination. Leaf nutrient concentrations, pollen germination, fruit set, leaf chlorophyll index, nut and kernel characteristics, vegetative growth, nut weight, and nut yield were measured to assess the effects of treatments. The results showed that all B and Zn applications and combinations had a significant effect on all traits except nut and kernel diameter, shell percent, husk thickness, and pistillate flower abscission (PFA). Pollen germination, fruit set, vegetative growth, nut weight, kernel percent, nut and kernel length, and chlorophyll index were highest when B and Zn were applied simultaneously at 174 and 1050 $mg \cdot L^{-1}$ concentrations, respectively.

Persian walnut is sensitive to B and Zn deficiency (Ramos, 1997), especially in sandy soils with low organic matter and also in calcareous soils (Storey, 2007). These conditions are predominant in many walnut orchards around the world, particularly in Iran (Momeni, 2003; Ziaeian and Malakouti, 2001). Boron and Zn deficiencies are more probable early in the season because the translocation of elements from the root to the aboveground portion may not be adequate before leaf expansion (Neilsen et al., 2004). Zinc and B have a critical effect on flowering and fruit set and for this reason spring foliar application of these elements are frequently recommended in walnut orchards. In soils with a strong Zn fixation capacity, spring foliar fertilization has several advantages including low application rate, uniform distribution of fertilizer materials, efficacy before leaf development, and quick response (Umer et al., 1999).

Severe B deficiency symptoms in walnut trees consist of long, leafless shoots, mostly in the tops of trees, and flattened and twisted shoots at the tips. These shoots die during the following winter. Moderate B deficiency in walnut results in reduced yields in otherwise healthy looking trees (Ramos, 1997). Boron plays an important role in pollen germination and pollen tube growth (Storey, 2007) and foliar sprays of B increase pollen germination in a number of tree species including almond [*Prumus amygdalus* (Nyomora et al., 1997)],

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Effect of nitrogen fertilisation rates on the content of fatty acids, sterols, tocopherols and phenolic compounds, and on the oxidative stability of walnuts

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The influence of nitrogen (N) fertilisation on the content of lipids and phenolic compounds in walnut kernels (cv. Chandler) has studied for three consecutive growing years. Moreover, a new technique (OXITEST) was set up to analyse the oxidative stability of the kernel directly from the whole sample. Significant differences in the fatty acid composition were observed, and linoleic acid was the main fatty acid present. N fertilisation reduced the oleic acid content relative to the control. High amounts of N increased the linoleic acid content and reduced the linolenic acid content. On the other hand, the control and the lower N fertilised samples had the highest levels of n-3 fatty acids. Comparing control and fertilised samples, there were no statistical differences in the sterol and tocopherol compositions (with the exception of α-tocopherol). With regard to phenolic content, N fertilisation had a significant negative effect on the phenolic compounds in walnut kernel samples. The OXITEST technique confirmed that the oxidative stability of kernels was related to the fatty acid composition and the PUFA (polyunsaturated fatty acid) content.