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Selection of late leafing, late flowering, laterally fruitful walnut (*Juglans regia*) types in Turkey

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Abstract In many areas of Turkey, walnut (*Juglans regia*) production is limited not only by winter cold but also by autumn and spring frosts that can damage the sensitive non-dormant tissues. This study was conducted to select late leafing and late flowering walnut types with high lateral fruitfulness within a seedling population in 1999–2001. The main objective of the selection programme was to select types that would not suffer injuries from late spring frost. As a result of the expeditionary observations 19 forms were selected, according to characteristics of late leafing, lateral fruitfulness, blight resistance, anthracnose, and codling moth tolerance. Then, selected forms were further evaluated according to nut characteristics after detailed analysis. The percentage of lateral fruitfulness of selected types was between 10% and 70%. The times of leafing of selected types were 10–20 days later than adjacent types.

Keywords *Juglans regia*; late leafing; lateral bud fruitfulness; germplasm

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INTRODUCTION

Annual world Persian (English) walnut (*Juglans regia*) production totalled 680 000 t in 2000. Of this, Turkey produced 125 000 t. There are 4.5 million natural seedling hybrid walnut trees on their own roots in Turkey. These trees are an important source of genetic diversity for *J. regia* in Turkey. The climatic diversity and high heterozygosity because of continuing sexual propagation have formed a very rich genetic material among this local walnut population. However, there is a concern that political and economic instability in the areas containing these natural seedling trees will result in continued and accelerated loss of *Juglans* genetic diversity (Akca 2001).

In Turkey, walnuts are mainly propagated generatively. The leading cultivars are 'Yalova 1', 'Yalova 3', 'Yalova 4', 'Sebin', and 'Bilecik'. Low yields are a problem in 'Yalova 1', 'Yalova 3', and 'Yalova 4'. None of these cultivars are late leafing and all are terminal bearing. 'Sebin' is a precocious and laterally fruitful cultivar. However, 'Sebin' requires chemical pest control for codling moth. 'Bilecik' is a crucial polliniser for 'Sebin'. 'Yalova 1' has vigorous growth and its crown is medium dense with leafing out at the beginning of April. 'Yalova 1' produces round to oval shaped nuts weighing 16 g with 50% kernel. It ripens in mid September. 'Yalova 3' has vigorous growth, starts leafing at the beginning of April, and produces smooth to oval shaped nuts weighing 12 g with 53% kernel. It ripens towards the end of September. 'Yalova 4' has medium growth with early April leafing out. It has smooth to round shaped nuts weighing 12 g with 52% kernel which ripen at the end of September. 'Sebin' has medium growth with 50% lateral bud fruitfulness. It starts leafing out at the beginning of April and has nuts averaging 11 g with 67% kernel. Ripening occurs at the end of September. 'Bilecik' tree growth is vigorous. Nut weight is 13 g with 51% kernel. It ripens at the end of September (Akca 2001).

In many areas of Turkey walnut production is limited by winter cold and by autumn and spring

frosts that damage the more sensitive non-dormant tissues. Our weather data show that the last spring frost occurs before 15 April in this region.

Walnut cultivars with late leafing can be cultivated in mountain areas, where the late frosts are frequent. Fruitfulness of lateral buds is very important because of the enhancement of the early bearing of young walnut trees and it is an important factor in yield of mature trees (Serr 1962; Forde 1979).

The genetic variation of native walnut populations presents many opportunities for walnut breeding. In view of the diversity of walnut seedling trees we took the opportunity to make selections within them, during 1990–2001. The aim of this study was to select new types combining lateral fruitfulness, late leaf break, resistance to bacterial blight (*Xanthomonas juglandis*), anthrachnosis (*Gnomonia leptostila*), and codling moth (*Cydia pomonella*).

MATERIALS AND METHODS

Selections were done in the middle Black Sea region of Turkey (in Niksar and Basçiftlik and its villages in Tokat) which have a total area of 1450 km^2. The trees were at various ages, but not younger than 15 years old. About 5000 walnut trees were investigated. Pre-selection was done according to leafing time. The types with early leafing were eliminated and late leafing trees were selected the first year. The trees with both late leafing and lateral bud fruitfulness also were selected in 1999–2000. For three consecutive years (1999–2001), data on phenology and yield characteristics were obtained from 19 trees of *J. regia*.

The observations made in the field were: date of budbreak, lateral bud fruitfulness, tree vigour, tree growth habit, altitude of the trees' growing site, blooming date of male and female flowers, and tolerance to anthracnose, bacterial blight, and codling moth. For 2 years (2000–01), data on pomology characteristics were obtained from 19 trees of *J. regia*. The observations taken in the laboratory for nuts and kernels were: nut and kernel weight, kernel percentage, nut dimensions (cheek, suture, length), shell thickness, kernel colour, ease of kernel removal, oil content, protein content, and ash content. The nut traits were measured using 10 nuts chosen randomly (McGranahan & Ramos 1992). The nuts were dried until the moisture content of the whole walnuts was reduced to less than 5%.

Also the selections were grafted on the seedling rootstocks (*J. regia*) to maintain a genetic resource for future researchers. The leafing date of selected trees was observed in 2002 at a single location, "common garden".

RESULTS AND DISCUSSION

As a result of the expeditionary observations in the selection zone, 19 walnut selections were collected, based on possession of: late leafing, lateral fruitfulness, blight resistance, anthracnose, and codling moth tolerance. Then the selections were further evaluated according to their nut characteristics.

Walnut improvement in this study emphasised late leafing, lateral fruitfulness, blight resistance, tolerance to anthracnose and codling moth. The most significant yield factor that can be manipulated through breeding is lateral bud fruitfulness, a bearing habit in which the current season's lateral buds produce flowers. Lateral fruitfulness is also associated with precocity (Serr 1962; Forde 1979). Selection for this character is particularly important in Turkey where for most walnut varieties, only terminal and subterminal buds produce shoots which bear pistillate flowers. Late leafing is also a particularly important character in Turkey where many areas have late spring frosts. Late leafing cultivars are also tolerant to bacterial blight in areas with spring rains and dry summers (Forde 1975). Combining these two characters will be of great benefit for Turkish walnut production.

The altitude at which selected trees were found varied from 739 to 1040 m. Tree age of selections ranged from 20 to 120 years. The selected walnut trees had 0.80–2.80 m trunk circumferences and 9–20 m tree height (Table 1). The tree habit and tree vigour of selected trees is listed in Table 1. Three years of observation for date of budbreak, lateral bud fruitfulness, and male and female blooming dates are presented in Table 2.

Late leafing is not common in Turkish walnut cultivars. However, it is a valuable characteristic. Cultivars of walnut that escape blight, insect pests, and early spring frosts are developed by selection for late leafing. Leafing time of the selected trees was 2 weeks later than the cultivars commonly grown in this region. The bloom period of the selections was from 15–21 April to 7–10 May in their original location which was later than other cultivars grown in the region. In its original location, BAS 18 is a very late leafing type compared with the other

Table 1 Tree characteristics of promising walnut (*Juglans regia*) types after selection from the middle Black Sea region of Turkey.

Selections	Altitude (m)	Age (estimated year)	Trunk circumference (cm)	Height (m)	Habit	Density of branch	Vigour
BAS 01	763	35	120	18	Semi-erect	Sparse	Strong
BAS 02	755	80	130	20	Semi-spreading	Medium	Medium
BAS 03	763	20	80	15	Erect	Very sparse	Strong
BAS 04	750	40	90	10	Semi-erect	Sparse	Strong
BAS 05	739	20	80	10	Spreading	Dense	Weak
BAS 06	1015	120	280	17	Spreading	Medium	Medium
BAS 07	1015	120	260	17	Erect	Dense	Medium
BAS 08	1040	40	150	13	Semi-spreading	Sparse	Strong
BAS 09	1033	45	150	20	Erect	Sparse	Strong
BAS 10	1020	65	110	14	Spreading	Medium	Medium
BAS 11	938	50	80	12	Spreading	Dense	Weak
BAS 12	938	40	90	15	Erect	Sparse	Strong
BAS 13	938	40	90	13	Semi-erect	Medium	Strong
BAS 14	941	50	120	15	Spreading	Dense	Weak
BAS 15	920	45	95	9	Spreading	Medium	Medium
BAS 16	893	40	120	18	Semi-spreading	Dense	Weak
BAS 17	900	90	140	20	Semi-spreading	Dense	Medium
BAS 18	890	35	80	10	Erect	Medium	Strong
BAS 19	855	50	130	20	Spreading	Dense	Weak
Sebin	640	10	45	7	Spreading	Dense	Medium

Table 2 Leafing time, flowering, and fruiting characteristics of selected walnut (*Juglans regia*) trees.

Selections	Leafing in original site	Leafing in same location	Dichogamy	Receptive period in female flowers	Pollen shedding	Fruitful laterals (%)	Harvest date
BAS 01	Apr II*	07 Apr	Protogynous	May II*	May IV*	30	Sep IV*
BAS 02	Apr III	13 Apr	Protogynous	Apr IV	May II	50	Sep II
BAS 03	Apr IV	22 Apr	Protandrous	Apr IV – May I	May II	20	Sep I
BAS 04	Apr IV	22 Apr	Homogamous	May II	May II	20	Sep III
BAS 05	Apr III	12 Apr	Protandrous	May II	Apr IV	50	Sep III
BAS 06	Apr IV	14 Apr	Protogynous	May II	Apr IV	50	Sep III
BAS 07	Apr IV	14 Apr	Protogynous	May I–II	May II	20	Sep III
BAS 08	Apr IV	15 Apr	Protogynous	May I–II	May II	40	Sep IV
BAS 09	Apr IV	15 Apr	Protandrous	May II	May IV	30	Oct I
BAS 10	Apr IV	14 Apr	Protandrous	May II	May I	70	Oct I
BAS 11	Apr IV	08 Apr	Homogamous	May II	May II	60	Oct I
BAS 12	Apr III	14 Apr	Protogynous	Apr IV – May I	May II	30	Oct I
BAS 13	Apr II	07 Apr	Protogynous	Apr IV	May II	40	Sep IV
BAS 14	Apr IV	18 Apr	Protandrous	May II	May I	50	Sep III
BAS 15	Apr III	14 Apr	Protandrous	May I	Apr IV	50	Sep III
BAS 16	Apr III	14 Apr	Protogynous	May I	May III	40	Sep III
BAS 17	Apr IV	17 Apr	Protogynous	May II	May IV	30	Sep IV
BAS 18	May I	22 Apr	Protogynous	May I	May III	10	Oct I
BAS 19	Apr III	14 Apr	Protogynous	May I	May II	40	Sep IV
Sebin	Apr III	10 Apr	Protandrous	May I	Apr IV	50	Sep II
LSD†						20	

*I, II, III, IV-monthly quarter.
†All means were compared by Fisher's protected LSD ($P < 0.01$).

selections in their original locations. But the leafing dates of BAS 18, BAS 03, and BAS 04 were the same when compared at a single location. These selections are 12 days late leafing compared with 'Sebin' in with the same location. The differences between the two observations (original location and same location) resulted from the altitude.

The ratio of lateral bud fruitfulness of selected types ranged between 10% and 70%. BAS 10 had the highest rate (70%) of lateral fruits. The number of nuts per cluster was determined as 1–3 in selected types (Table 2). The genetic factors of yield for an individual tree include bearing habit, the number of flowering shoots, and the number of flowers per shoot. Fruit set, nut and kernel weight, and lateral fruitfulness are important in yield determination for walnut.

A high percentage of fruitful lateral buds is not common in old European and American cultivars, but new walnut cultivars are mostly laterally fruitful. For instance, some of the cultivars which are laterally fruitful include 'Chandler', 'Vina', and 'Sundland' from the UC-Davis (University of California, Davis) breeding programme (Hendricks et al. 1985) and 'Lara' from France, an open pollinated offspring of 'Payne' (Charlot & Germain 1987). The ratio of lateral bud fruitfulness of 'Payne', 'Sundland', and 'Chandler' ranged from 80% to 87%.

The lateral fruit bearing varieties are susceptible to spring frosts and bacterial blight and have an early leafing out. Germain (1985) said that the percentages of lateral bud fruit bearing hybrids were fairly well correlated with early leafing. The most urgent goal for the Turkish improvement of walnut tree characters must be to associate high lateral bud fruitfulness and late leafing out. BAS 06, BAS 10, BAS 11, and BAS 14 had late leafing and good lateral bud fruitfulness in their original locations. The ratio of lateral bud fruitfulness of 'Sebin' is 50%.

Most selections had good field resistance against bacterial blight, anthrachnosis, and codling moth despite there being many affected trees. In the years and locations that climatic conditions favoured the spread of these diseases, no infection was observed on the selected types. However, severe infections were observed on neighbouring trees. Serr (1964) suggested that the wild walnut forests of north-eastern Turkey, which are growing under heavy rainfall, including summer rains, should be evaluated for potential blight resistance.

With respect to dichogamy, 11 types are protogynous, six selections protandrous, and two selections are homogamous (Table 2).

The harvest date from selected trees varied from the end of September to the beginning of October (Table 2). Germplasm with shorter growing seasons is probably available but it is difficult to make comparisons from the literature because growing seasons are often not defined and may begin with leafing or flowering and end with nut maturity, harvest, drop, or leaf drop (McGranahan & Leslie 1991). Except for BAS 03, all the selections had harvest dates later than 'Sebin'.

Selected types cropped regularly every year. There was an opportunity to assess the cold resistance of selected trees during the 3-year period between 1999 and 2001. Although many trees were damaged from late spring frosts, selected trees were not and were found tolerant to winter cold temperatures as low as –25°C in this area.

With respect to field characteristics there was substantial improvement relative to the control 'Sebin'. Lateral fruitfulness was increased by 20%, and leafing out date by up to 12 days. BAS 14 is the best selection for lateral fruitfulness and leafing out date.

The ideal nut should have a clean, strong, thin shell, a tight seal, and weigh between 12 and 18 g. The kernel should be easily removable from the shell, uniformly light in colour, clean, and weigh 6–10 g or at least 50% of entire nut weight. Nut and kernel quality is strongly affected by genotype, environment and their interaction (McGranahan & Leslie 1990).

The mean nut suture length of selected types was between 2.34 (BAS 07) and 3.28 cm (BAS 14), the average nut length of selected types was between 3.00 (BAS 06) and 4.03 cm (BAS 13). The mean nut cheek of selected types ranged between 2.45 (BAS 07) and 3.44 cm (BAS 08). The mean nut weight of selected types varied from 6.40 (BAS 04) and 12.75 g (BAS 13) and kernel weight from 2.56 (BAS 04) to 5.81 g (BAS 13). Kernel ratio was between 40.00% (BAS 04) and 67.70% (BAS 03) (Table 3). The kernel weight and kernel ratio of all the selected trees was poor compared with 'Sebin'.

Differences between pomological characteristics of selected trees were statistically significant (for all characters $P < 0.000$) except for oil content ($P < 0.086$). The results were consistent across 2 years of observations. Thus, we have not seen any year effect on our results for any characteristics of Table 3.

In selections, nut weight and kernel weight were less than found in selected types by other researchers in Turkey (Ölez 1971; Sen 1980; Akca 1994). Nut weight of selections and surveyed seedling

Table 3 Nut traits of selected types were evaluated according to their nut characteristics in their original locations.

Selections	Suture (cm)	Length (cm)	Cheek (cm)	Shell thickness (mm)	Weight (g)	Kernel weight (g)	Kernel ratio (%)	Kernel colour	Oil content (%)	Protein content (%)	Ash content (%)
BAS 01	2.75	3.36	3.03	0.71	8.33	4.43	53.18	Light	55.24	18.00	1.60
BAS 02	3.02	3.73	3.25	1.12	11.33	4.93	43.51	Light	57.71	17.00	1.40
BAS 03	2.86	3.31	3.18	0.97	7.48	5.06	71.67	Light	48.81	20.00	1.60
BAS 04	2.81	3.04	3.00	1.38	6.40	2.56	40.00	Light	41.78	20.00	2.20
BAS 05	2.68	3.51	2.86	1.03	8.45	4.98	58.93	Light	53.10	19.20	1.40
BAS 06	2.54	3.00	2.57	1.20	6.81	3.44	50.51	Light	60.80	22.00	2.10
BAS 07	2.34	3.29	2.45	1.39	5.98	2.98	49.83	Light	55.95	19.00	2.00
BAS 08	3.21	3.88	3.44	2.20	11.39	5.45	47.84	Light	46.41	23.00	1.80
BAS 09	2.78	3.65	3.09	2.32	9.71	4.24	43.66	Light	47.54	21.00	2.36
BAS 10	2.71	3.32	2.74	1.27	8.63	4.38	50.73	Extra light	50.45	16.40	1.92
BAS 11	2.52	3.03	2.77	1.92	7.73	4.14	53.55	Light	49.05	16.40	2.00
BAS 12	2.67	3.19	2.81	1.47	8.87	5.04	56.82	Light	59.75	21.60	1.68
BAS 13	2.75	4.03	3.22	2.03	12.75	5.81	45.56	Light	63.34	15.00	1.70
BAS 14	3.28	3.36	3.25	1.68	10.89	5.72	52.52	Light	63.10	16.60	2.04
BAS 15	2.93	3.45	3.19	1.45	10.29	5.22	51.50	Light	53.38	24.00	2.30
BAS 16	2.89	3.28	3.06	1.39	9.76	5.61	57.47	Light	56.05	16.00	1.60
BAS 17	2.86	3.30	3.13	1.34	9.90	4.72	47.67	Light	60.29	16.00	1.90
BAS 18	2.76	3.57	2.84	1.68	9.11	4.50	49.36	Light	48.90	16.60	1.60
BAS 19	3.08	3.73	2.98	1.38	9.66	5.81	60.14	Light	64.11	20.00	1.80
Sebin	3.15	3.62	3.24	0.65	11.00	7.00	67.64	Light	65.00	18.00	1.70
LSD*	0.12	0.06	0,08	0.23	1.46	0.44	4.97	–	5.70	1.60	0.15

*All means were compared by Fisher's protected LSD ($P < 0.01$).

populations ranged between 17 g and 26 g in Yugoslavia (Kuzmanovski et al. 1976), Bulgaria (Popov 1983), and Moldavia (Tsurkan et al. 1974; Komanich 1980), but less than 4 g in southern Kirghizia (Zarubin 1954). Average nut weights of commercial cultivars in California range between 17.5 g and 10.6 g for 'Sundland' to even less for 'Chico'. Mean kernel weights of cultivars is from 9.9 (Sundland) to 5 g. A high kernel percentage is desirable commercially for shipping and processing efficiency although an excessively high percentage indicates thin shells with poor strength. California cultivars 'Sundland' and 'Serr' and the Yugoslavian cultivar 'Champion' yield up to 60% kernel whereas 'Franquette' and 'Hartley' yield only 45–46% (Serr 1964; Reid 1987; McGranahan & Leslie 1990).

Shell thickness of selected types ranged between 0.90 (BAS 01) and 2.32 mm (BAS 09). Although there is some evidence to the contrary, the literature is generally in agreement that shell thickness of promising walnut cultivars is usually between 0.7 and 1.5 mm, according to Zhadan & Strukov (1977). Promising walnut types should have a shell thickness of between 0.7 and 1.5 mm. Nenjuhin (1971) suggested the optimum shell thickness of 0.92 mm. Only two of the selections (BAS 01 and BAS 03) were around this optima.

The kernel's removal was easy for all selections except for the BAS 06. The dominant colour of kernels and shells was light for all selections except for the kernel colour of BAS 10 which was extra light.

The fat content of selections varied between 41.78% (BAS 04) and 64.11% (BAS 19). The protein content was determined between 15.66% (BAS 17) and 24.40% (BAS 15). The ash content of selected types varied between 1.40% and 2.38% (Table 3). Pandele (1968), said that the protein content must be at least 16% and fat content at least 65%. Thus although adequate in protein content, all the selections were either low or very low in oil content. In the work of Akca (1994), protein content and oil content of 41 selected walnut types varied from 16.1 to 26.1% and 61.6 to 76.9% respectively. The oil content of selections was lower than 'Sebin'. However, 10 selections have more oil content than 'Sebin'.

CONCLUSION

Nut quality of the selected types was poor compared with the Turkish walnut cultivar 'Sebin'; however, these types may offer promise for walnut improvement as genetic resources for late leafing and lateral bud fruitfulness. Overall the best quality line among selected trees was BAS 14 because of late leafing, lateral fruitfulness, and nut quality. It produces oval shaped nuts weighing 10.89 g with 52.52% of kernel. BAS 14, BAS 06, BAS 10, and BAS 11 are the most promising selections. Results of the present study may help to improve economically sustainable walnut production in the middle Black Sea region.

AVAILABILITY

The most promising types can be obtained from the author.

REFERENCES

Akca, Y. 1994: Studies on selection of walnut (*Juglans regia*) in Gürün. Progress in temperate fruit breeding. Pp. 179–181.

Akca, Y. 2001: An overview of walnut cultivation in Turkey. National conference on walnuts September 5–8, Gaziosmanpasa University, Turkey. Pp. 298–307.

Charlot, G.; Germain, E. 1988: Le noyer-nouvelles techniques. Paris, Centre Techniques Interprofessionnel des Fruits et Legumes.

Forde, H. I. 1975: Walnut. *In*: Janick, J.; Moore, J. N. *ed*. Advances in fruit breeding. West Lafayette, Indiana, Purdue University Press.

Forde, H. I. 1979: Persian walnut in the western United States. *In*: Jaynes, R. A. *ed*. Nut tree culture in North America. Hamden, Connecticut, North Nut Growers Association. Pp. 84–97.

Germain, E. 1985: A breeding programme to develop new late flowering, early bearing and high yielding walnut varieties (*Juglans regia*): preliminary results. 5e Colloque Recherché Fruitier/Bordeaux. Pp. 157–174. (In French.)

Hendricks, L. C.; McGranahan, G. H.; Ramos, D. E.; Iwarkiri, B.; Forde, H. I. 1985: Walnut orchard management. *In*: Ramos, D. E. *ed*. Establishing the walnut orchard. Oaklanda, California, Division of Agricultural National Research. University of California, Publication 21410. Pp. 46–51.

Komanich, I. G. 1980: Biology, cultivation and breeding of walnut. Kishinev, Moldavian SSR. Shtiinsta Publisher. (In Russian.)

Kuzmanovski, I.; Georgiev, D.; Popovski, R. 1976: Biological and ecological properties of some selected biotypes of walnut in Macedonia. *Jugoslovensko Vocarstva 10(37/38)*: 417–424.

McGranahan, G.; Leslie C. 1991: Walnuts *'Juglans regia'*. *Acta Horticulturae 290*: 901–951.

McGranahan, G.; Ramos, D. E. 1992: 'Tulare' Persian walnut. *HortScience 27*: 186–187.

Nenjuhin, V. N. 1971: Selection of plus trees of the walnut in Ukraine. *Plant Breeding Abstract 41(1)*: 187.

Ölez, H. 1971: Studies on breeding by selection of Marmara Region walnuts. Yalova, Atatürk Horticultural Research Institute. (In Turkish.)

Pandele, I. 1968: Biochemical characterization of the principal varieties and types of walnut, almond and hazel in Rumania and determination of general metabolic correlations specifics to nuts. *Plant Breeding Abstract 38*: 871.

Popov, S. 1983: Phenological peculiarities of some species, sorts and forms of genus *Juglans*. *Gorskostopanska Nauka 5*: 26–34. (In Bulgarian.)

Reid, W. 1987: Persian walnuts in Yugoslavia. *Annual Report of Northern Nut Growers Association 78*: 159–164.

Sen, S. M. 1980: Studies on breeding by selection of walnuts of North Eastern Anatolia and Eastern Black Sea Region. Agriculture Faculty, Atatürk University, Erzurum. (In Turkish.)

Serr, E. F. 1962: Selecting suitable walnut varieties. Davis, California, California Agricultural Experiment Station. P. 144.

Serr, E. F. 1964: The nut crops of Turkey. *Proceedings of the Nut Growers Society of Oregon and Washington 50*: 11–22.

Tsurkan, I.; Semenchenko, S. P.; Zelenko, V. G. 1974: On increasing the qualities of walnut production in Russian Sadovodstvo. *Vinogradarstvo I Vinodelia Moldavaii 7*: 11–12.

Zarubin, A. F. 1954: Reclamation and development of walnut and fruit in southern Kirghizia. Moscow, Academy of Science of the USSR, Institue of Forestry. Translated from Russian by Israel Program for Scientific Translation. Washington, D.C., USDA and NSF.

Zhadan, V. M.; Strukov, M. V. 1977: Breeding walnut for fruit size. *Plant Breeding Abstract 47(11)*: 918.