Europ.J.Hort.Sci., **70** (2). S. 89–95, 2005, ISSN 1611-4426. © Verlag Eugen Ulmer GmbH & Co. Stuttgart

Investigating the Possibility of Fruiting Primocane Raspberries for Off-Season Production in Cyprus.

D. Neocleous[1)], I. Papadopoulos[1)] and M. Vasilakakis[2)]
([1)]Agricultural Research Institute, Ministry of Agriculture, Natural Resources and Environment, Nicosia, Cyprus and [2)]Department of Horticulture and Viticulture, Aristotle University of Thessaloniki, Thessaloniki, Greece)

Summary

Dormant single cane (15 cm) plants of 'Autumn Bliss' and 'Polana', primocane-fruiting red raspberry (*Rubus idaeus* L.) plants from the UK, were sent to the Agricultural Research Institute of Cyprus in December 2001 after they had already received an unknown amount of field chilling (x days). The plant material after arrival was additionally chilled at 4 °C in order to escalate the production and to ensure an adequate fruiting since for raspberry production chilling plays a significant role. The treatments were x, x+16 and x+32 days of chilling. Afterwards the plants were planted in a soilless plant bed system in an unheated plastic greenhouse. The planting density was 4.1 canes m^{-2}. 'Autumn Bliss' had greater cane vigour, flowered earlier, and produced a higher yield with acceptable berry mass, while 'Polana' did not produce flowers in time to yield a sufficient crop before summer (21 June 2002). The additional chilling (AC) reduced cane length, node number, and leaf area for both cultivars but no clear influence was observed on internode length, cane diameter and time to flowering. AC increased the number of fruiting nodes and berry mass for 'Autumn Bliss', whereas this result was not the case in 'Polana'.

Our study confirms the hypothesis that raspberries can grow and be produced efficiently in the semi-arid climate of Cyprus. These results also imply that there may be a good prospect for an off-season production system for primocane-fruiting red raspberries in Cyprus and Southern Europe.

Zusammenfassung

Machbarkeitsanalyse zum Anbau von am einjährigen Holz fruchtenden Himbeeren außerhalb der Saison auf Zypern. Ruhende eintriebige (15 cm) Pflanzen der am einjährigen Holz fruchtenden Himbeer- (*Rubus idaeus* L.) Sorten 'Autumn Bliss' und 'Polana' wurden im Dezember 2001 von Großbritanien an das Agricultural Research Institute auf Zypern geschickt, nachdem sie bereits eine unbekannte Summe (x Tage) Kühltage auf dem Feld verbracht hatten. Nach der Ankunft wurde das Pflanzenmaterial zusätzlich bei 4 °C kältebehandelt, um die Erntemenge zu steigern und sicherzustellen, da die Kältebehandlung bei der Himbeerproduktion eine wichtige Rolle spielt. Die Behandlungen dauerten x, x+16 bzw. x+32 Kühltage. Anschließend wurden die Pflanzen in einem unbeheizten Kunststoffgewächshaus in ein erdeloses Pflanzsystem ausgepflanzt. Die Pflanzweite betrug 4.1 Triebe m^{-2}. 'Autumn Bliss' wies ein stärkeres Wachstum auf, blühte früher und produzierte eine größere Erntemenge mit akzeptabler Beerenmasse, während 'Polana' nicht rechtzeitig blühte, um vor dem Sommer (21. Juni 2002) eine ausreichende Erntemenge zu erzielen. Die zusätzliche Kühlung (AC) reduzierte bei beiden Sorten die Trieblänge, die Nodienzahl, und die Blattfläche, wohingegen bei der Internodienlänge, dem Triebdurchmesser und der Dauer bis zur Blüte kein deutlicher Einfluss nachweisbar war. Bei 'Autumn Bliss' erhöht AC die Anzahl fruchtender Nodien und die Beerenmasse, während dies bei 'Polana' nicht der Fall war.

Unsere Untersuchung stützt die Hypothese, dass Himbeeren im semiariden Klima auf Zypern erfolgreich angebaut werden können. Die Ergebnisse deuten außerdem daraufhin, dass eine gute Perspektive für den Anbau von am einjährigen Holz fruchtenden roten Himbeeren außerhalb der Saison auf Zypern und in Südeuropa besteht.

Key words. *Rubus idaeus* – 'Autumn Bliss' – 'Polana' – chilling – primocane-fruiting – soilless – protected cultivation

Introduction

Off-season raspberry production has been attempted in the milder growing areas of Europe. Europeans have already begun to explore the winter production of floricane-fruiting type in greenhouses (PRITTS et al. 1999). The production of raspberries outside the main summer cropping season in the UK is increasingly depen-

dent on long-cane systems (BRENNAN et al. 1999). OLIVEIRA et al. (1996, 1999) used summer-cuttings of primocane-fruiting red raspberries to induce off-season fruit production under protected cultivation in mild winter climates. The importance of the primocane-fruiting trait in red raspberries (*Rubus idaeus* L.), for off-season production, could create better market opportunities and the development of primocane-fruiting allo-polyploid *Rubus* hybrids means that an extra crop can be harvested in areas with mild winters and expands the areas and seasons of production (ROSATI et al. 1999). Similarly several crops per year might be harvested in tropical and sub-tropical climates (LOPEZ-MEDINA and MOORE 1999). Primocane red raspberries initiate flowers independently of the photoperiod and temperature (VASILAKAKIS et al. 1979, 1980; LOCKSHIN and ELLFVING 1981; TAKEDA 1993), although solar radiation, photoperiod, and temperature are closely related with early flowering (PRIVE et al. 1993; VASILAKAKIS 1997; LOPEZ-MEDINA and MOORE 1999). Off-season raspberry production may include the use of growth regulators for shortening the time to flower induction and chilling period requirements (CRANDALL and GARTH 1981; BRAUN and GARTH 1984; GHORA et al. 1999), chemical dormancy breaking in sub-tropical regions (SNIR 1986), high nitrogen levels and temperatures (LOCKSHIN and ELFVING 1981) and vernalisation of the plants at different growth stages (VASILAKAKIS et al. 1980; TAKEDA 1993). Low temperatures are generally accepted as the most important factor required for dormancy release in several plants. Cold treatment applied to primocane-fruiting red raspberries at any stage of plant growth affects the time of flowering and plant height (VASILAKAKIS and DANA 1978). For raspberry production chilling plays a significant role. When grown in mild climates, in countries such as Israel, Australia, Mexico and Chile, bud dormancy is often not lost by the time temperatures rise in spring (CAREW et al. 2000). This can lead to serious problems in growth such as:

1. Poor and delayed bud break and foliar growth, leading to reduced leaf area.
2. Sparse and abnormal flower development.
3. Poor fruit set.

Natural or artificial low temperatures ≤7 °C are best for chilling. Chilling not only removes raspberry dormancy but also anticipates flowering through vernalisation. Flowering was much earlier for 'Autumn Bliss' when plants were chilled as roots or young shoots (CAREW et al. 2001). Likewise VASILAKAKIS et al. (1980) found that in 'Heritage', a primocane-fruiting cultivar, low temperature at any plant stage development shortens the seasonal cycle. However, the increasing interest in producing raspberries in warmer climates requires a greater understanding of chilling effects, especially in primocane-fruiting cultivars (CAREW et al. 2000). This study investigates the possibility of fruiting primocane raspberries for off-season production under protected conditions and soilless cultivation in Cyprus.

Materials and Methods

An experiment was established for late spring-early summer production of primocane-fruiting red raspberries in the Agricultural Research Institute of Cyprus (long. 32 °E, lat. 35 °N). Dormant single cane (15 cm) plants of 'Autumn Bliss' and 'Polana', primocane-fruiting red raspberry cultivars, grown in the UK (R-W Walpole Ltd., Ivy Farm, Terrington St. Clement, King's Lynn, Norfolk), were collected and sent to the Agricultural Research Institute in December 2001. The plant material was divided into three groups. Each group consisted of 32 plants of each cultivar. The first group planted in the greenhouse and the second and third groups were held at 4 °C for 16 and 32 days respectively. Following chilling, canes were removed from the cold store and placed in soilless culture under natural (non-heated or photoperiod) greenhouse conditions. The plants were grown in a polyethylene-coated, omega type, unheated multi-span plastic greenhouse, which was 4 m high, 14 m wide and 20 m long with side openings, shaded up to 60 %. The primocanes were planted in elevated polygal plant beds (Ramat-Hashofet, Israel) with perlite (horticultural grade perlite 3.0–5.0 mm) as planting media in 6 m rows in a closed soilless system. Rows were oriented east to west with a distance of 0.4 m between plants and 1.2 m between channels. Three primocanes per plant were allowed to grow (4.1 primocanes m^{-2}) while others were counted and removed. Plants were grown for 24 weeks from December 2001 to June 2002 in a greenhouse where the temperature averaged 29 °C day/10 °C night, the relative humidity averaged 39 % day/93 % night and the photosynthetic active radiation (PAR) fluctuated from December to June between 550 and 850 μmol m^{-2} s^{-1} (Model L1-6200, LI-COR, Lincoln, Nebr., USA). Sensors were placed in the root environment and started the water pump when moisture dropped below the saturation point controlled irrigation-fertigation. In-line drip irrigation tubing (spaghetti) with 0.4 m spaced emitters providing 3.5-liters h^{-1} was placed in the row. The plants were fertigated with a balanced hydroponic nutrient solution alternated with water as needed. The nutrient solution consisted of (ppm): N (150), P (65), K (280), Ca (170), Mg (50), S (103), Fe (1.7), Mn (1), Cu (0.02), B (0.5), Zn (0.25), and Mo (0.05). Iron was applied in chelated Fe-EDDHA form. The pH of the solution was maintained at 6.5 and EC at 1.9 mS cm^{-1}. Leaf tissue analyses were conducted to point out any effects of soilless cultivation on leaf mineral nutrient concentrations. Mature leaves of the vegetative growth were collected, dried; and finely ground. Element concentrations of Ca, Mg, Fe, Mn, Cu, and Zn in solutions were quantified on an inductively coupled argon plasma spectrophotometer (Instrumentation Laboratory Model S12) (ALLAN 1971). Element concentrations of N and P were quantified in a Continuous Flow Analyser (Chemlab Instruments Ltd.), K by flame emission spectrophotometer (CHARALAMPOUS and PAPAKONSTANTINOU 1965) and Cl^- by Nelson method (1960).

Insects and diseases were controlled using IPM practices. Pests were controlled successfully with a combination of: a) physical control using yellow traps painted with glue and hung between raspberry plants; b) biological control using Neemex (Azadirachtin) and Naturallis (Beauveria bassiana); c) chemical control with the insecticide Tracer (Spinosad) and acaricide

Apollo (Clofentazine). There were no disease problems during the growth cycle. The plants were sprayed once with copper sulphate at an early stage of growth. Bumble-bees (*Bombus terrestris*) were introduced at flowering for pollination (Bio-Bee, Israel). The hive was placed 1m above the ground, in a protected place. The colony had a life of 10 weeks and consisted of 80–100 bees. The experiment was designed as a randomised complete-block with 4 replicates of 6 treatments. Each experimental unit consisted of 4 plants (12 canes) with 2 sample canes. Data were analysed using the means procedure of SAS/ASSIST: analysis of variance (SAS Institute, Cary, N.C.).

The following characteristics for the two primocane-fruiting red raspberry cultivars were measured: a) Vegetative growth: cane length, overall mean internode length, diameter of the cane (50 cm above the planting media), total node number/cane, total leaf area/cane (CID, Ins., USA), average leaflet area and total number of secondary shoots; b) Reproductive development: total fruiting nodes/cane and number of flowers and fruits/cane, flowering progress, yield/cane and berry mass. Fruits were picked twice a week, counted, and weighed.

Results and Discussion

Visual observations of the plants indicated no growth limiting supply. Leaf nutrient contents (% dry matter) were: N (4.23), P (0.45), K (1.88), Ca (0.75), Mg (0.40), Cl (0.45) and (ppm): Fe (120), Mn (250), Cu (8), Zn (60). CALLESEN (1991) reported that according to VANG-PETERSEN (1989) the optimum mineral contents (% of dry matter) of raspberry leaves are: N (2.8–3.3), K (1.2–1.6), Ca (1.0–1.5), Mg (0.2–0.4), and P (0.15–0.25). In this experiment, although N, P, and K were above this range, no leaf discoloration or growth retardation was observed. Studies of primocane-fruiting red raspberries grown in hydroponic conditions with different nitrogen concentrations showed that the greatest leaf, stem and root dry weight accumulation was

Table 1. Growth components of red raspberry cultivars 'Autumn Bliss' and 'Polana' (primocane-fruiting).

Cultivar	Cane length (cm)	Cane diameter (cm)	Total node no.	Fruiting nodes no.	Leaf area (m^2/cane)	Leaflet area (cm^2)	Yield (g/cane)	Berry mass (g)
'Autumn Bliss'	187.5 a	9.58 a	38.4 a	17.8 a	1.23 a	64.0 a	369 a	2.42 b
'Polana'	152.9 b	8.32 b	36.1 b	17.5 a	0.89 b	65.7 a	209 b	2.64 a

Means followed by the same letters in the same column are not significantly different, (Duncan's multiple range test P≤0.05).

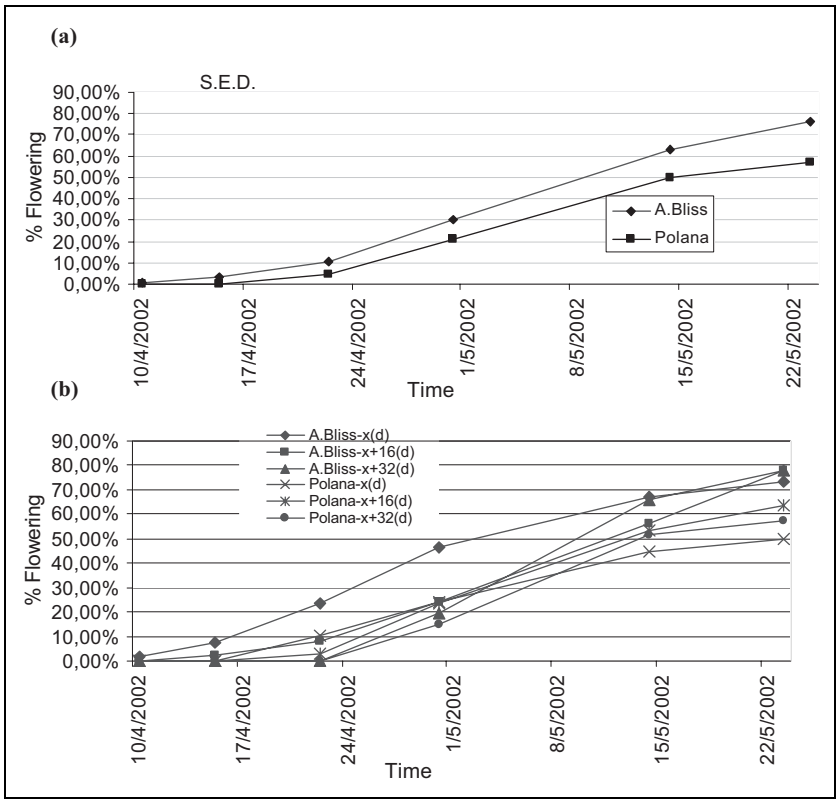


Fig. 1. (a) Flowering progress of 'Autumn Bliss' and 'Polana', and (b) the effect of chilling treatments (x, x+16 and x+32 days) on the flowering progress in each cultivar (x: unknown amount of chilling). The % flowering percentage was calculated as the quotient of the number of flowered canes (anthesis of the terminal flower) concerning the total number of canes.

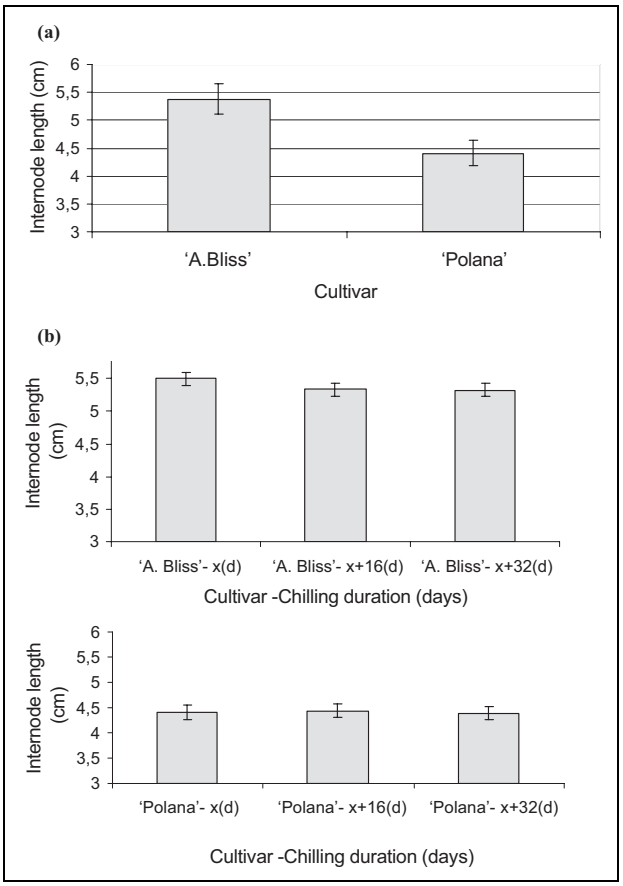


Fig. 2. (a) Overall mean internode length of 'Autumn Bliss' and 'Polana', and (b) the effect of chilling treatments (x, x+16 and x+32 days) on mean internode length in each cultivar (with standard errors, $P \leq 0.05$) (x: unknown amount of chilling).

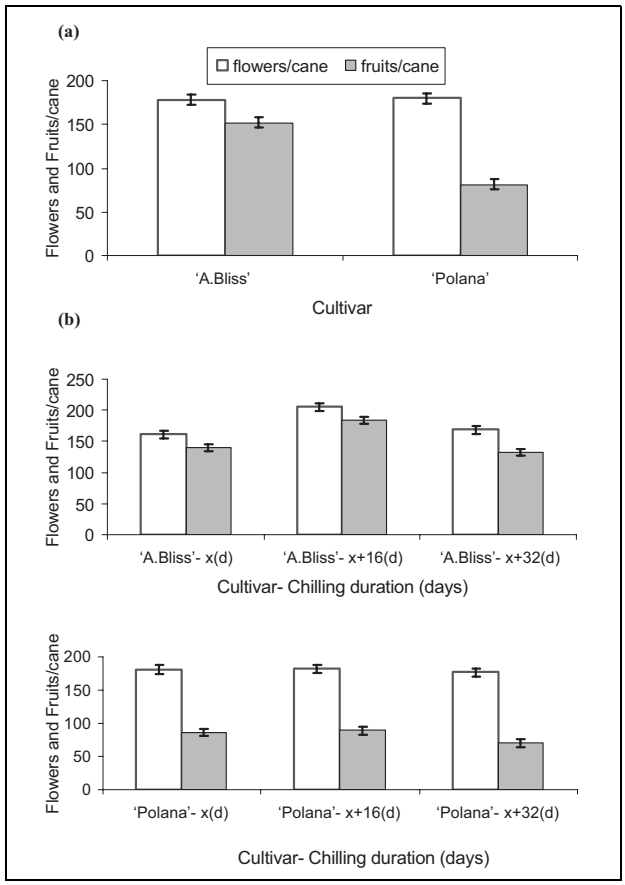


Fig. 3. (a) Number of flowers/cane and fruits/cane of 'Autumn Bliss' and 'Polana' raspberry cultivars, and (b) the effect of chilling treatments (x, x+16 and x+32 days) on the number of flowers and fruits/cane in each cultivar (with standard errors concerning the same columns, *P≤0.05)* (x: unknown amount of chilling).

Table 2a. Growth components of 'Autumn Bliss', a primocane-fruiting red raspberry, under different chilling treatments.

Cultivar	Growth components							
	Chilling treatment (days)	Cane length (cm)	Leaf area (m^2/cane)	Cane diameter (cm)	Total node no.	Fruiting nodes	Yield (g/cane)	Berry mass (g)
'Autumn Bliss'	x	202 a	1.31 a	9.33 abc	39.61 a	16.56 b	302.15 b	2.16 c
	x+16	192 a	1.17 ab	9.90 a	38.45 ab	18.21 a	458.81 a	2.49 b
	x+32	168 b	1.14 ab	9.49 ab	37.07 abc	17.90 a	345.45 b	2.60 ab

found in the 10-meq N/litre concentrations and the greatest numbers of nodes, flowers and inflorescences per cane were found in the 5, 10, and 20-meq N/litre concentrations (HIMELRICK et al. 1994). 'Autumn Bliss' had greater cane vigour (length, internode length, diameter and leaf area) and grew faster than 'Polana', with the result to be earlier in flowering and bearing fruits of an acceptable berry mass and higher yield (Table 1, Fig. 1a and 2a). 'Polana' did not flower early enough to bear fruits prior to 21 June 2002 and for this reason the plants did not reach the final harvest date (their late maturity resulted in lower yield) (Fig. 1a and 3a). Different leaf area of the fruiting canes in the two cultivars 'Autumn Bliss' and 'Polana' resulted from the unequal number of leaves per cane rather than asymmetrical sizes of the leaves (Table 1). Previous investigations (WRIGHT and WAISTER 1982) related cane leaf area and leaf number to increased yield and leaf-photosynthetic carbohydrates were the most probable source for fruit production. Additional chilling (AC) reduced cane length, node number, and leaf area for both cultivars (Table 2a and b) but no clear influence was observed on internode length, cane diameter and time to flowering (Table 2a and b, Fig. 1b and 2b). AC increased the number of fruiting nodes and berry mass for 'Autumn Bliss', whereas this result was not the case in 'Polana' (Table 2a and b). Under the particular conditions of the experiment the findings do not agree

Table 2b. Growth components of 'Polana', a primocane-fruiting red raspberry, under different chilling treatments.

Cultivar	Growth components							
	Chilling treatment (days)	Cane length (cm)	Leaf area (m^2/cane)	Cane diameter (cm)	Total node no.	Fruiting nodes	Yield (g/cane)	Berry mass (g)
Polana	x	169 a	0.94 a	8.05 a	39.35 a	17.79 a	237.66 a	2.78 a
	x+16	149 b	0.90 a	8.26 ab	35.76 bc	18.06 a	232.31 a	2.62 ab
	x+32	139 b	0.76 b	8.67 ab	33.84 c	17.58 a	165.96 b	2.59 ab

x: unknown amount of chilling.
Means followed by the same letters in the same column are not significantly different (Duncan's multiple range test, P≤0.05)

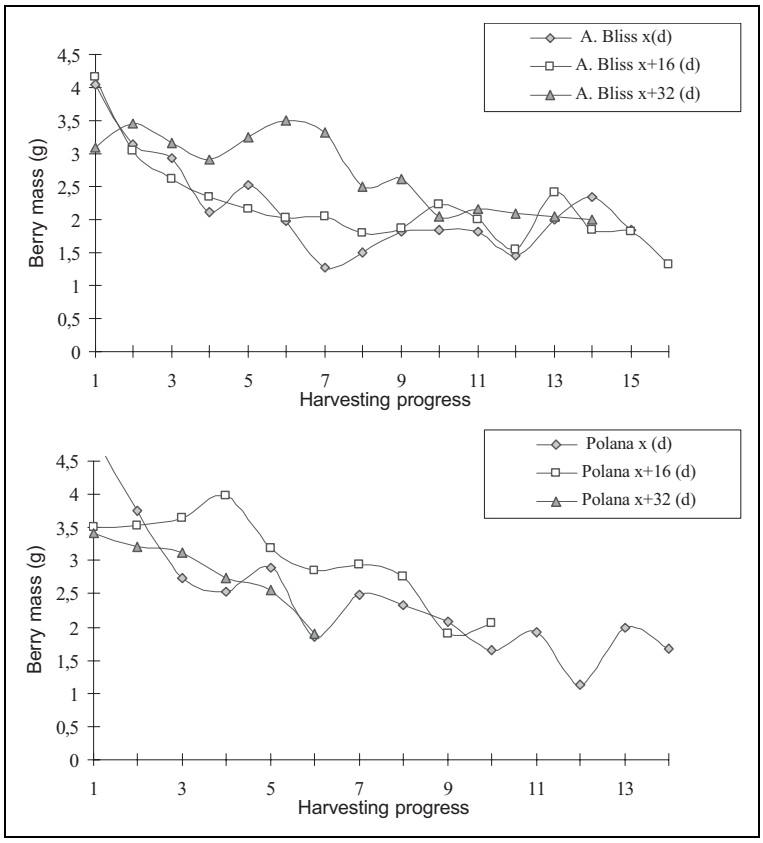


Fig. 4. The effect of chilling treatments (x, x+16 and x+32 days) on the berry mass, of raspberry cultivars 'Autumn Bliss' and 'Polana' (primocane-fruiting), through successive harvestings (x: unknown amount of chilling).

with previous observations (VASILAKAKIS et al. 1979, 1980; PRIVE and SULLIVAN 1991; TAKEDA 1993) that chilled plants flowered earlier or with the findings according to VASILAKAKIS and DANA (1978) who recorded that cold treatment applied to primocane-fruiting red raspberry 'Heritage' at any stage of plant growth affects the time of flowering and plant length but the number of nodes with inflorescences was unaltered. Mean berry mass declined with harvest date for both cultivars (Fig. 4). These results are in agreement with the results found by DEGOMEZ et al. (1986). Yield did not increase with longer chilling duration for both cultivars and 'Autumn Bliss' for 16 d AC gave the highest yield (Table 2a and b). Additional chilling of 32 d did not increase the number of flowers or fruits per cane in both cultivars while 'Autumn Bliss' produced 25 % more flowers when additionally chilled for 16 d (Fig. 3b). 'Autumn Bliss' produced fewer canes than 'Polana' (Fig. 5a). AC reduced cane production in 'Autumn Bliss' while this was not the case with 'Polana' (Fig. 5b). To summarize, the results indicate that the plants had received adequate chilling at arrival in Cyprus, and that the additional chilling (AC) imposed by the authors in Cyprus contributed little to accumulation of chilling units (hours at 4 °C) and it failed to give a clear outcome even that it had significant effects on some vegetative and reproductive components. 'Autumn Bliss' was better performing than 'Polana' and displayed superior traits before 21 June 2002. 'Polana' was not sufficiently adapted to the Cyprus environment and for this reason the plants did not reach the final harvest date and their late maturity resulted in lower yield.

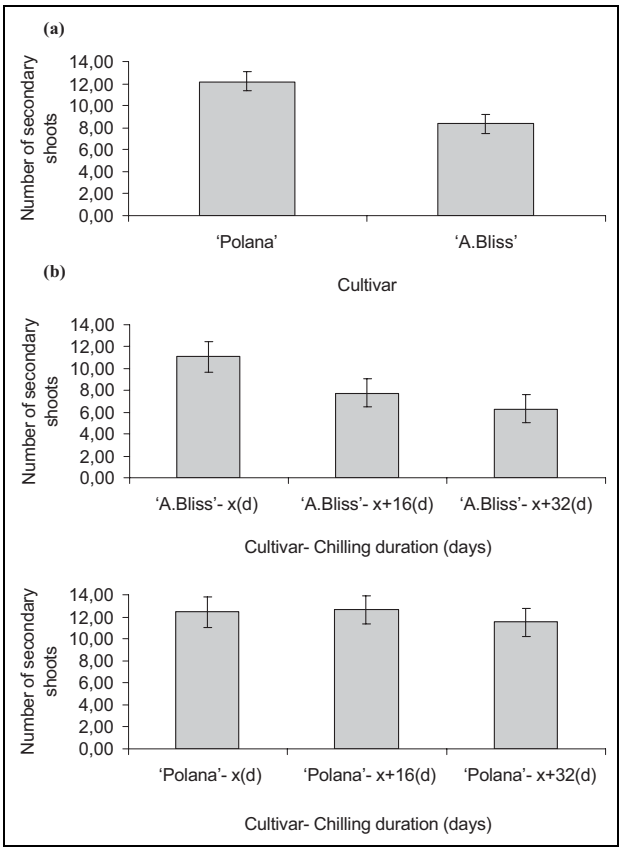


Fig. 5. The number of secondary shoots of raspberry cultivars 'Autumn Bliss' and 'Polana' until 6 June 2002, and (b) the effect of chilling treatments (x, x+16 and x+32 days) on the average number of secondary shoots in each cultivar until 6 June 2002 (with standard errors, P≤0.05) (x: unknown amount of chilling).

The results show that our study confirms that raspberries can be produced efficiently in the semi-arid climate of Cyprus. If a suitable cultivar is used, these results imply that there may be good potential for an off-season production system for primocane-fruiting red raspberries in Cyprus and Southern Europe. Optimal timing, crop management and cultivar use, would allow extending raspberry production in Cyprus from October to May. However the direction for future research may be to stagger harvests over a long period of time. Several approaches are to be taken to open the possibility for a profitable production system with a minimal vernalisation period for primocane-fruiting raspberries. Furthermore, efforts should be made to avoid high temperature during summer at low energy cost. Certainly these parameters will be derived by experience.

Acknowledgement

A portion of the thesis in partial fulfilment of the requirements for the degree of PhD.

Research supported by Onassis Foundation, Aisxinou 4, 105 58 Athens, Greece.

References

ALLAN, J. E. 1971: The preparation of agricultural samples for analysis by atomic absorption spectroscopy. Ruakura Soil Research Station, Hamilton, New Zealand, pp.14.

BRAUN, J. W. and J. K. L. GARTH 1984: Growth and fruiting of 'Heritage' primocane-fruiting red raspberry in response to daminozide and ethephon. J. Amer. Soc. Hort. Sci. **109**, 207–209.

BRENNAN, R. M., R. MCNICOL, T. GILLEPSIE and S. RAFFLE 1999: Factors affecting out-of season *Rubus* production. Acta Horticulturae **505**, 115–120.

CALLESEN, O 1991: Drip irrigation and fertigation of raspberry. Tidsskrift for Planteavl **95**, 411–415.

CAREW, J., T. GILLESPIE, J. WHITE, H. WAINWRIGHT, R. BRENNAN and N. BATTEY 2000: The control of the annual growth cycle in raspberry. J. Hort. Sci. & Biotechn. **75**, 495–503.

CAREW, J. G., K. MAHMOOD, J. DARBY, P. HADLEY and N. BATTEY 2001: The effects of low temperature on the vegetative growth and flowering of the primocane fruiting raspberry 'Autumn Bliss'. J. Hort. Sci. & Biotechn. **76**, 264–270.

CHARALAMBOUS, J. and J. PAPAKONSTANTINOU 1965: Methods of analysis for agricultural research workers. A laboratory Handbook. Agr. Res. Institute, Nicosia, Cyprus, pp. 11–32.

CRANDALL, P. C. and J. K. L. GARTH 1981: Yield and growth response of 'Heritage' raspberry to daminozide and ethephon. Hortscience **16**, 654–655.

DEGOMEZ, T. E., L. W. MARTIN and P. J. BREEN 1986: Effect of nitrogen and pruning on primocane fruiting red raspberry 'Amity'. HortScience 21, 441–442.

GHORA, Y., M. VASILAKAKIS and G. STAVROULAKIS 1999: Effect of growth retardants (Cycocel, Daminozide and Paclobutrazol) on growth and development of red raspberries, cultivar 'Autumn Bliss', cultivated under plastic greenhouse conditions in Chania, Crete, Greece. Acta Horticulturae **513**, 453–460.

HIMELRICK, D. G. and W. A. DOZIER 1994: Effect of nitrate concentration on hydroponically-grown primocane-fruiting red raspberries. J. Plant Nutrition **17**, 85–198.

LOCKSHIN, L. S. and D. C. ELFVING 1981: Flowering Response of 'Heritage' Red Raspberry to Temperature and Nitrogen. HortScience **16**, 527–528.

LOPEZ-MEDINA, J. and J. N. MOORE 1999: HortScience **34**, 638–640.

NELSON, R. A. 1960: Potentiometric determination of the chloride content of tobacco. J. Assoc. Anal. Chem. **43**, 518.

OLIVEIRA, P. B., C. M. OLIVEIRA, L. LOPES-DA-FONSECA and A. A. MONTEIRO 1996: Off-season production of primocane-fruiting red raspberry using summer pruning and polyethylene tunnels. HortScience **31**, 805–807.

OLIVEIRA, P. B., C. M. OLIVEIRA, L. LOPES-DA-FONSECA and A. A. MONTEIRO 1999: Summer pruning intensity affects on off-season production of primocane-fruiting red raspberries. Acta Horticulturae **505**, 101–106.

PRITTS, M. P., R. W. LANGHANS, T. H. WHITLOW, M. J. KELLY and A. ROBERTS 1999: Winter Raspberry Production in Greenhouses. Hort Technology **9**, 13–15.

PRIVE, J. P. and J. A. SULLIVAN 1991: Performance of tis-

sue-cultured primocane-fruiting red raspberries following chilling. HortScience **26**, 590–592.

PRIVE, J. P., J. A. SULLIVAN, J. T. A. PROCTOR and O. B. ALLEN 1993: Climate influences vegetative and reproductive components of primocane-fruiting red raspberry cultivars. J. Amer. Soc. Hort. Sci. **118**, 393–399.

ROSATI, P., B. MEZZETTI, V. KNIGHT, K. Y. LIM, V. TRAJKOVSKY, B. SJOSTEDT, I. GRECO, G. MARTELLI, S. LIONAKI, G. STAVROYLAKIS, M.CIORDA and A. POLLEDO. 1999: Expanding the adaptation and production area of *Rubus* in Europe. Acta Horticulturae **505**, 39–45.

SNIR, I. 1986: Growing Raspberries under subtropical conditions. Acta horticulturae **183**, 183–190.

TAKEDA, F. 1993: Chilling affects flowering of primocane-fruiting 'Heritage' red raspberry. Acta Horticulturae **352**, 247–252.

VANG-PETERSEN, O. 1989: Godskning af trae-og busk-frugt. Gron Viden, Havebrug nr. **31**.

VASILAKAKIS, M. D. and M. N. DANA 1978: Influence of primocane inflorescence removal on number of inflorescences and suckers in 'Heritage' red raspberry. HortScience **13**, 700–701.

VASILAKAKIS, M. D., B. E. STRUCKMEYER and M. N. DANA 1979: Temperature and development of red raspberry flower buds. J. Amer. Soc. Hort. Sci. **104**, 750–751.

VASILAKAKIS, M. D., B. H. MCCOWN, and M. N. DANA 1980: Low temperature and flowering of primocane-fruiting of red raspberries. HortScience **15**, 750–751.

VASILAKAKIS, M. 1997: Red Raspberries. Small fruits. Dedousi Press, Aristotle University of Thessaloniki. p. 125–185.

WRIGHT, C. J. and P. D. WAISTER 1982: Within-plant competition in the red raspberry. II. Fruiting cane growth. Journal of Horticultural Science **57**, 437–442.

Received March 16, 2004 / Accepted January 25, 2005

Addresses of authors: Damianos Neocleous and Ioannis Papadopoulos, Agricultural Research Institute, Ministry of Agriculture, Natural Resources and Environment, P.O. Box 22016, 1516 Nicosia, Cyprus and Miltiadis Vasilakakis, Department of Horticulture and Viticulture, Aristotle University of Thessaloniki, Thessaloniki 540.06, Greece, e-mail: d.neocleous@arinet.ari.gov.cy.