Current Trends in Natural Sciences Vol. 6, Issue 11, pp. 85-92, 2017

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

STUDIES ON THE *IN VITRO* MICROPROPAGATION ABILITY OF *ARONIA MELANOCARPA* (MICHX.) ELLIOT

Nicoleta Anca Şuțan [1,*], Valentina Isac [2], Cristina Duminică [1], Aurel Popescu [1]

[1] University of Pitești, Faculty of Science, Targul din Vale Street, No.1, Arges, Romania
[2] Research Institute for Fruit Growing, Pitești, Romania

Abstract
Since the expression of a high ability for in vitro regeneration and proliferation is a very important condition for any biotechnological approach for clonal propagation, the influence of genotype and culture medium composition on the number of shoots regenerated and their length in successive subcultures was investigated in Aronia melanocarpa (Michx.) Elliot cultivars 'Melrom' and 'Nero'. Chokeberry cultivar 'Nero' showed a significantly higher ability of regeneration compared to the cultivar 'Melrom', the greatest number of shoots being obtained with the basal medium containing MS macroelements, LF microelements and LF vitamins, supplemented with 4,5 mg×dm^{-3} BA and 0,6 mg×dm^{-3} IBA.

Keywords: Aronia melanocarpa, axilary shoots, culture medium, genotype.

1. INTRODUCTION

From its spread in Europe, in the middle of the last century, *Aronia melanocarpa* (Michx.) Elliot was remarked, especially, by high content of phenolic compounds and carotenoids in its fruits, but also by their richness in dietary fibers, proteins, minerals,vitamins, and organic acids (Lehmann, 1990; Mayer-Miebach et al., 2008; Oszmianski and Wojdylo, 2005; Tanaka and Tanaka, 2001; Wawer *et al*., 2006), which are assigned a variety of protective and curative properties.Berries, juice or extracts of *A. melanocarpa* (Michx.) Elliot were the subject of numerous studies aimed at highlighting their potential health benefits. Thus, from the researches on the antioxidant (Wu et al., 2004; Oszmianski and Wojdylo, 2005; Seeram et al., 2008*)* hepatoprotective *(*Kowalczyk et al., 2003; Valcheva-Kuzmanova et al., 2004), cardioprotective (Bell and Burt, 2007) and hypoglycaemic effects (Simeonov et al., 2002), to those on antimutagenic (Duthie et al., 2007) and antitumoral effects (Bermudez-Soto et al., 2007), or those on protective action againstdegenerative diseases,the scientific literatureis rich in informationoutlining their prophylactic and therapeutic properties, without suggests on any unwanted or side effectof their use (Kokotkiewicz et al., 2010).
In vitro micropropagation represents most often a quick, economical and safetechnique for multiplication of valuable varieties (cultivars) of trees and shrubs. Since 1990s, various cultivars of *A. melanocarpa* (Michx.) Elliot, popular for their horticultural characteristics, were tested for their *in vitro* micropropagation ability (Brand and Cullina, 1992; Litwińczuk, 2002; Litwińczuk, 2013; Kwak et al., 2015). Among the most popular varieties of *A. melanocarpa* (Michx.) Elliot are

*Corresponding author, E-mail address: ancasutan@yahoo.com

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

'Nero','Rubina', 'Viking', 'Kurkumäcki', 'Hugin', 'Fertödi' and 'Aron' (Strigl et al., 1995, McKay, 2004, cited by Kulling and Rawel, 2008).

The main objective of our studies was to determine the *in vitro* regeneration and proliferation ability of the Romanian chokeberry cultivar 'Melrom' (released in 2016), compared to cultivar 'Nero'. In order to optimize the in vitro micropropagation process was analyzed the influence of the culture medium composition on the number of shoots regenerated and their lengths in successive subcultures.

2. MATERIAL AND METHODS

The explants from 'Nero' and 'Melrom' cultivars of *A. melanocarpa* (Michx.) Elliot tested for their ability of regeneration and proliferation*in vitro*were obtained from field-grown plants in the small fruits collection of the Research Institute for Fruit Growing, Pitești-Mărăcineni.

The cultivar 'Nero', very popular, produce berries which remain on the plant until the late autumn, with a long storage life. 'Melrom'is a Romanian black chokeberry cultivar created at the Research Institute for Fruit Growing Pitești-Mărăcineni, and released in 2016. This cultivar has morphological characteristics similar to that of 'Nero' cultivar, but distinguishes by its larger fruits.

In vitro culture initiation. In april 2016, branches of *A. melanocarpa* (Michx.) Elliot, cultivars 'Nero' and 'Melrom', were harvested from the field-grown plants and pre-sterilized by washing in tap water to which 2-3 drops of Domestos were added. Subsequently, lateral buds were disinfected successively with 96% ethanol for 5 minute sand with 6% calciumhypochlorite for 10 minutes. After sterilization, the biologicalmaterial was rinsed in three baths of distilled water.

Shoot apices with 2-3 leaf primordia and sizes of 0,1 - 0,3 mm were excised from the sterilized foliar buds and distributed individually into Pyrex tubes of 20-25 cm^3, containing 10 ml of culture medium sterilized by autoclaving. For this stage, the culture medium has been solidified as an inclined plane.

The culture medium containing Lee-Fossard macroelements, microelementsand vitamins, 20 $g \times dm^{-3}$sucrose, 0,1mg $\times dm^{-3}$giberellic acid (GA_3) and 1mg $\times dm^{-3}$benzyladenine (BA) was solidified with 7g/l agar. The pH of the culturemediumwas adjusted to 5,7 with0,1NKOH before autoclaving for 20 minutes at 121 ^{0}C.

Micropropagation by axillary shoot proliferation. Microshoots obtained after the initiation of *in vitro* culture were divided and transffered into Ehrlenmayer flasks of 100cm^3 capacity, containing 30 ml ofculture mediumcomposed of Murashige-Skoog (MS)macroelements, Lee-Fossard (LF) microelements and Linsmaier-Skoog (LS) vitamins (Table 1), 40$g \times dm^{-3}$dextrose and solidifiedwith 8$g \times dm^{-3}$agar. For each of the two cultivars investigated for their micropropagation ability, were tested culture media optimized by supplementation with 0,3 $mg \times dm^{-3}$ GA_3, BA in concentration of either 3 $mg \times dm^{-3}$or 4,5 $mg \times dm^{-3}$, and IBA in concentration ofeither 0,3 $mg \times dm^{-3}$or 0,6 $mg \times dm^{-3}$. The experimental treatments with various combinations and concentrations of growth regulators are shown in Table 1. The culture flasks were sealed with plugs of cotton wrapped in aluminium foil and then autoclaved. The same treatments were used in three successive subcultures of 'Nero' and 'Melrom' shoots.

Shoot apices culturea and microshoots cultures, respectively, were incubated in a growth chamber at 22-24°C, under a photoperiod of 16 hours light /8 hours darkness, and a light intensity of 40 $\mu mol\ m^{-2}\ s^{-1}$.

To avoid major statistical errors, each treatment was replicated in six culture flasks, each of them containing five microshoots. Observations were made every four weeks, at the time of shoots separation from the formed clusters and their subcultivation of fresh medium (with the same

*Corresponding author, E-mail address: ancasutan@yahoo.com

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

composition). The multiplication rate was calculated from the ratio between the number of shoots regenerated per explant cultivated *in vitro* and the number of initial shoots in each subculture, for each of the culture medium used for micropropagation.
Processing of data obtained from the experiments of micropropagation was performed by analysis of variance with Duncan's Multiple-Range test, using the SPSS for Windows, version 16.0 (2007). The experimental results (mean values and percentage values) are presented and analyzed in this paper in several relevant graphics.

Table 1.Composition of the culture medium used for*in vitro*micropropagation of shoots in 'Nero' and'Melrom' cultivars of*A. melanocarpa* (Michx.) Elliot

Treatment	Basal medium	Growth regulators (mg × dm^{-3})		
		GA_3	BA	IBA
V1	Macroelements MS n, Microelements LF n, Vitamins LS n	0,1	1,00	0,1
V2	Macroelements MS n, Microelements LF n, Vitamins LS n	0,1	1,50	0,1
V3	Macroelements MS n, Microelements LF n, Vitamins LS n	0,1	1,00	0,2
V4	Macroelements MS n, Microelements LF n, Vitamins LS n	0,1	1,50	0,2

3. RESULTS AND DISCUSSION

The influence of genotype and culturemediumon the in vitro multiplicationrate. Rinsing of the buds of *Aronia melanocarpa* (Michx.) Elliotwith 96% ethanol and 6%calciumhypochlorite resulted in an effective surface sterilization, with a contamination percentage of less than 12% of explants.
The calculated value of regeneration ability of shoot apices originating from mature donor plants was 86,6%. Statistical analysis of the results revealed that the potential of micropropagation by axillary shoot formation in cultivar 'Nero' was significantly influenced by the composition of the culture medium. Increased concentrations of auxin and cytokinin (V4) induced a higher rate of shoot multiplication in cultivar 'Melrom', and a significantly higher rate in cultivar 'Nero', compared to the other three treatments (Fig. 1).In this context, it should be noted that for the *in vitro* stimulation of regeneration of shoots from axillary buds of *A. melanocarpa* (Michx.) Elliot, the basal media used most often were MS, half-strengthMS,and Woody Plant Medium(Brand and Cullina, 1990; Litwińczuk, 2013;Kwak *et al*., 2015).The significant difference in the shoot proliferation ability of the two studied chokeberry cultivars can be attributed to the influence of genotype. Similar results were obtained by Kwak *et al*. (2015), who reported a higher rate of proliferation in cultivar 'Nero', compared to cultivars'Purple', 'Mackenzie', 'Viking' and 'Odamamachiko', on WPM culture medium supplemented only with 1,0 mg×dm^{-3}zeatin. In the study carried out by us, the greater number of microshoots regeneratedin cultivar'Nero', regardless

http://www.natsci.upit.ro
*Corresponding author, E-mail address: ancasutan@yahoo.com

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

of the composition of the culture medium, can be attributed to the growth regulators balance, defined by a substantially higher concentration of cytokinin.

The frequency of shoot regeneration in successive subcultures.For both 'Nero' and 'Melrom', the potential of shoot regeneration from axillary buds and proliferation during the three subcultures was increasing (Fig. 2). Regardless of the composition of the culture medium, cultivar 'Nero' showed a statistically significant higher frequency of shoot regeneration during the all three successive subcultures, compared to cultivar 'Melrom'.

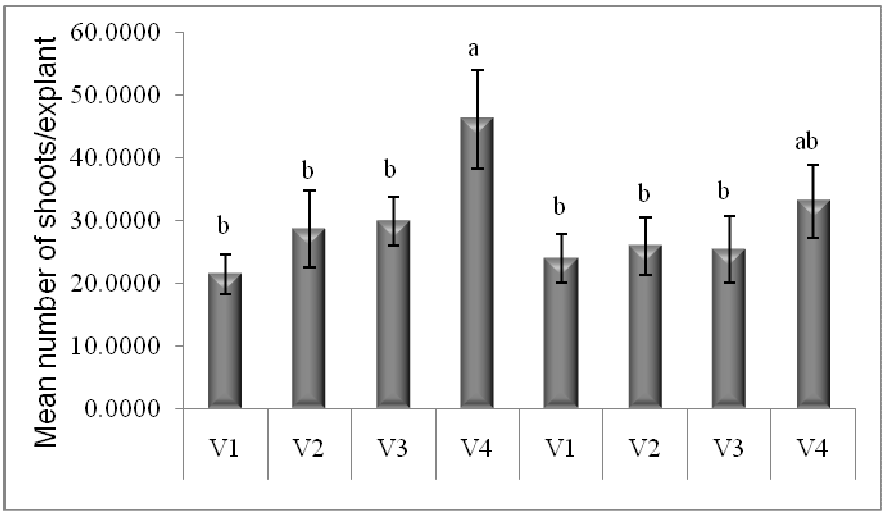

Figure 1. The influence of genotype andculture medium on the in vitroshoot multiplicationrate incultivars 'Nero' and 'Melrom' of A. melanocarpa (Michx.) Elliot (bars represent standard deviationof the mean; a, b: interpretation of the significance of differences by theDuncan test, p<0,05).

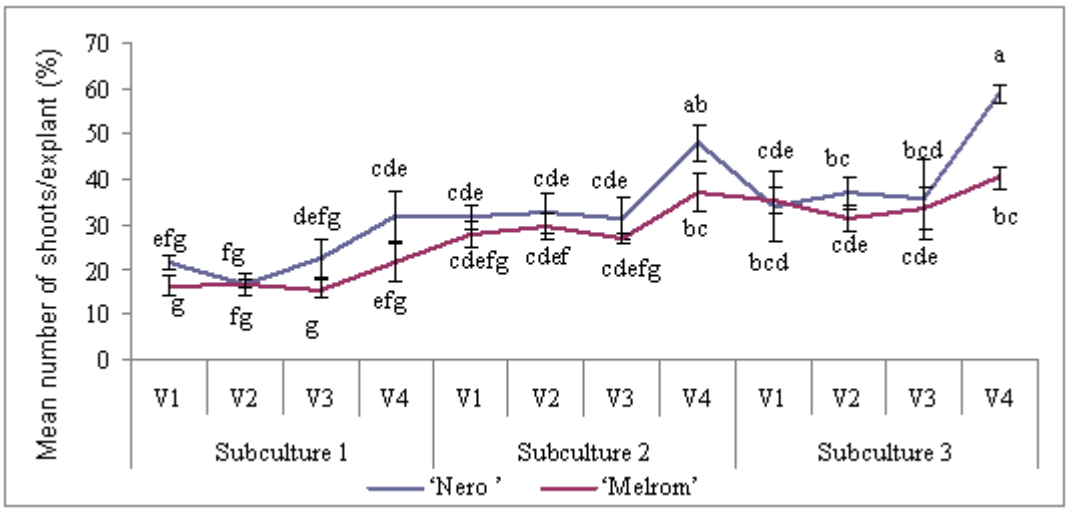

Figure2. Shoot proliferation rate incultivars'Nero'and 'Melrom' ofA. melanocarpa (Michx.) Elliotin successive subcultures(bars represent standard deviationof the mean; a, b, c, d, e, f, g: interpretation of the significance of differences by the Duncan test, p<0,05)

*Corresponding author, E-mail address: ancasutan@yahoo.com

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

The influence of genotype and composition ofculturemediumon the length of shoots. Compared to the cultivar 'Melrom', shoot length was greater and significantly higher in cultivar 'Nero', excepting those regenerated in treatment V3, defined by a lower concentration of BA and a high concentration of IBA. However, it should be pointed out that, on average, shoots regenerated on the culture medium from V1 treatment were significantly higher, which is likely to reflect the influence of the cytokinin-auxin balance on cell proliferation. Also, the different response of the two chokeberry cultivars to the*in vitro* environment confirm the influence of genotype on the ability of cellular proliferation and regeneration *in vitro*. Actually, the studies on the micropropagation ability of various species of trees and shrubs, such as *Ribes uva-crispa* (Wainwright and Flegmann, 1986), *Rubus idaeus* (Popescu and Isac, 2000; Isac and Popescu, 2009), *Vaccinium macrocarpon* (Debnath and McRae, 2001), *Rubus chamaemorus* (Martinussen et al., 2004), *Vaccinium vitis-idaea* (Debnath, 2005), *Rubus fruticosus*and *Ribes nigrum* (Ruzic and Lazic, 2006), *Sorbus aucuparia* (Lall *et al.*, 2006), *Arbustus unedo* (Gomes and Canhoto, 2009), *Ribes rubrum* (Sedlák and Paprštein, 2012), *Paulownia*ssp. (Shtereva et al., 2014)*Prunus dulcis* (Choudhary et al., 2015), and many other species, such as *Fragaria* and *Potentilla* (Isac et al., 1994; Șuțan et al., 2010), revealed the influence (from slight to strong) of genotype.

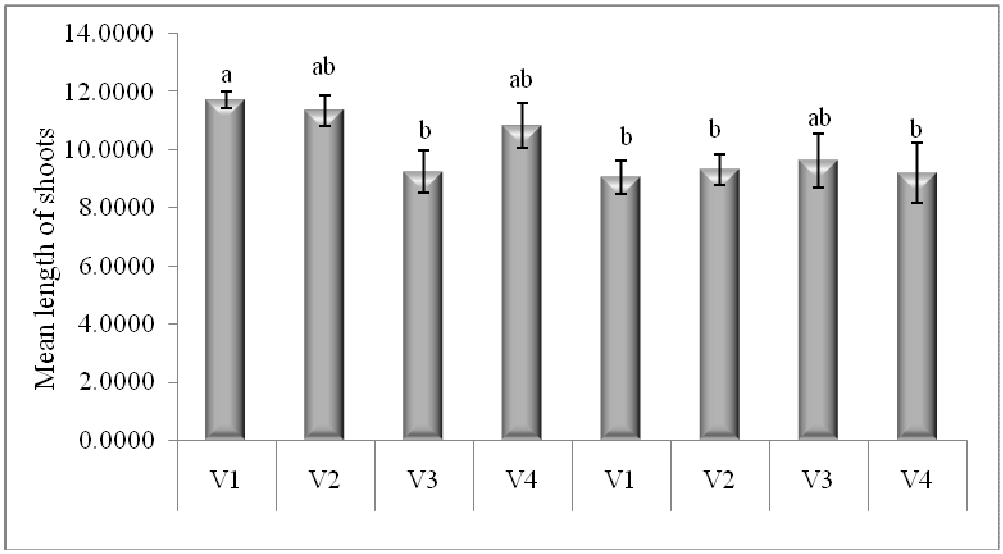

Figure 3. The influence of genotype and composition of culturemediumon the length of shoots in cultivars 'Nero' and 'Melrom' ofA. melanocarpa (Michx.) Elliot (bars represent standard deviation ofthe mean; a, b: interpretation of the significance of differences by the Duncan test, p<0,05)

As shown in figure 4, in both chokeberry cultivars studied, the cell proliferation was not significantly influenced by the number of subcultures.

In both 'Nero' and 'Melrom', the analysis of correlation between the number of shoots and the shoot length, by calculating the Pearson's correlation coefficient, showed a very weak inverse correlation between these two parameters, with r=-0,091 in cultivar 'Melrom', and r= -0,098 in cultivar 'Nero', respectively.

*Corresponding author, E-mail address: ancasutan@yahoo.com

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

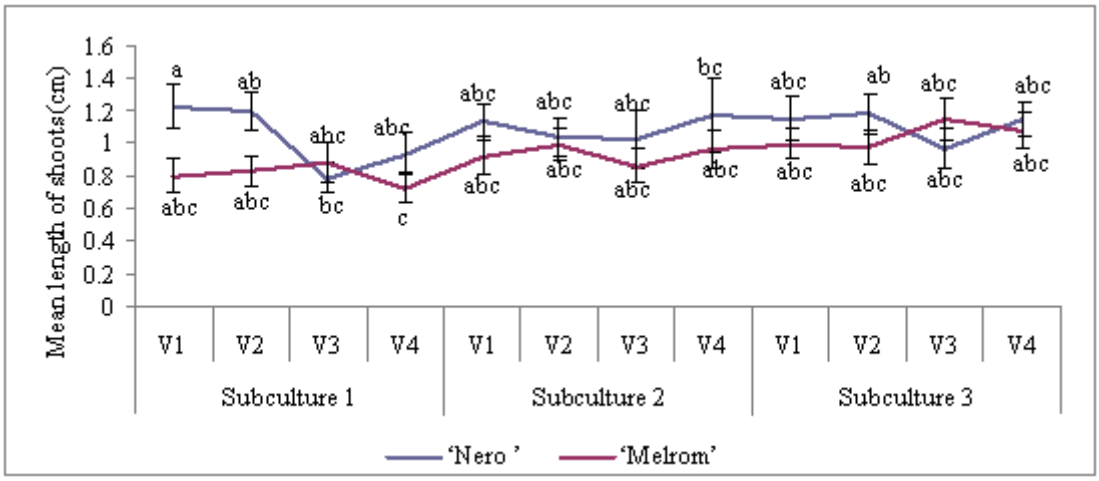

Figure 4. The influence of the number of subcultures on the length ofshoots (bars represent standard deviation ofthe mean; a, b, c: interpretation of the significance of differences by the Duncan test, p<0,05)

4. CONCLUSIONS

The influence of genotype proved to be extremely important in the *in vitro* micropropagation of chokeberry cultivars 'Nero' and 'Melrom', revealing the higher potential of cell proliferation and shoot regeneration of 'Nero'. Regardless of the genotype and culture medium, the *in vitro* shoot multiplication rate was increasing during the first three subcultures. The overall results of our study showed also that the ratio of auxin, cytokinin and giberelic acidis important for maintaining a proper growth of shoots in length during the successive subcultures.

5. ACKNOWLEDGEMENTS

This paper was published under the project ADER 3.3.1/2015.

6. REFERENCES

Bell, D.R., Burt, T.D. (2007). Phenolic acids contained in anthocyanin enriched extracts from elderberry, bilberry and chokeberry possess endothelium dependent and independent vasorelaxation properties in porcine coronary arteries. *Faseb J., 21,* A366.

Bermudez-Soto, M.J., Larrosa, M., Garcia-Cantalejo, J.M., Espin, J.C., TomasBarberan, F.A., Garcia-Conesa, M., (2007). Up-regulation of tumor suppressor carcinoembryonic antigen-related cell adhesion molecule 1 in human colon cancer Caco-2 cells following repetitive exposure to dietary levels of a polyphenol-rich chokeberry juice. *J. Nutr. Biochem., 18,* 259-271.

Brand, M.H., Cullina W.G. (1990). Micropropagation of *Aronia arbutifolia* and *A. melanocarpa. HortScience, 25(9),* 1096.

Brand, M.H., Cullina W.G. (1992). Micropropagation of red and black chokeberry (*Aronia* spp.). *HortScience, 27(1),* 81.

Choudhary, R., Chaudhury, R., Malik, S.K., Sharma, K.C., 2015. An efficient regeneration and rapid micropropagation protocol for almond using dormant axillary buds as explants. *Indian J. Exp. Biol., 53,* 462-467.

Debnath, S. (2005). Micropropagation of lingonberry: influence of genotype, explant orientation, and overcoming TDZ-induced inhibition of shoot elongation using zeatin. *HortScience, 40,* 185-188.

Debnath, S.C., McRae, K.B. (2001).An efficient *in vitro* shoot propagation of cranberry (*Vaccinium macrocarpon* Ait.) by axillary bud proliferation. *In Vitro Cell. Dev. Biol.-Plant37,* 243-249.

Duthie, S.J. (2007). Berry phytochemicals, genomic stability and cancer: evidence for chemoprotection at several stages in the carcinogenic process. *Mol. Nutr. Food. Res., 51,* 665-674.

*Corresponding author, E-mail address: ancasutan@yahoo.com

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

Gomes, F., Canhoto, J.(2009). Micropropagation of strawberry tree (*Arbustus unedo* L.) from adult plants. *In Vitro Cell. Dev. Biol.-Plant, 45,* 72-82.

Isac, V., Popescu, A., Coman, M. (1994). Studies on plant regeneration from tissue-derived callus in *Fragaria* × *ananassa* Duch. In: Progress in Temperate Fruit Breeding, H. Schmidt and M. Kellerhals (Eds.), Kluwer Acad. Publishers.

Isac, V., Popescu, A. (2009). Protocols for *In Vitro* Micropropagation of Raspberry, and PlantRegeneration by Organogenesis.A Guide to Some *In Vitro* Techniques – Small Fruits.B. Mezzetti, Đ. Ružić, and A. Gajdosova (eds). Grafika Jureš, Čačak, Serbia.

Kane, M.E., Dehgan, B., Sheehan, T.J., 1991. *In vitro* propagation of Florida native plants: *Aronia arbutifolia*. *Proc. Fla State Hort. Soc.,104,* 207-290.

Kokotkiewicz, A., Jaremicz, Z.,Luczkiewicz M. (2010).*Aronia* Plants: A Review of Traditional Use, Biological Activities, and Perspectives for Modern Medicine. *J. Med. Food, 13(2),* 255-269.

Kowalczyk, E., Kopff, A., Fijalkowski, P., Kopff, M., Niedworok, J., Blaszczyk, J. Kedziora J., Tyślerowicz P.(2003). Effect of anthocyanins on selected biochemical parameters in rats exposed to cadmium. *Acta Biochim. Pol., 50,*543-548.

Kwak, M.C., Choi, C.H., Choi, Y.E., Moon, H.K., 2015. Micropropagation of *Aronia* (*Aronia melanocarpa* Elliot, black chokeberry) and its 5 varieties. *J. Plant Biotechnol., 42,* 380-387.

Kulling, S.E., Rawel, H.M., 2008. Chokeberry *(Aronia melanocarpa)* – A review on the characteristic components and potential health. *Planta Med.,74,* 1625-1634.

Lall, S., Mandegaran, Z., Roberts, A. (2006). Shoot multiplication and adventitious regeneration in *Sorbus aucuparia*. *Plant Cell Tissue and Organ Culture 85(1),* 23-29.

Lee, E.C.M., de Fossard, R.A. (1977). Some factors affecting multiple bud formation of strawberry *Fragaria x ananassa in vitro*. *Acta Horticulturae, 78,* 187-195.

Lehmann, H., (1990). Die Aroniabeere und ihre Verarbeitung. *Flüssiges Obst., 57,* 746-752.

Linsmaier, E.M., Skoog, F. (1965). Organic growth factor requirements of tobacco tissue cultures. *Physiol. Plant., 18,* 100-127.

Litwińczuk, W. (2002). Propagation of black chokeberry (*Aronia melanocarpa* Elliot) through *in vitro* culture. *Electr. J. Pol. Agric. Univ., 5(2),* #06.

Litwińczuk, W. (2013). Micropropagation of chokeberry by *in vitro* axillary shoot proliferation.*Methods Mol. Biol., 11013,* 179-186.

Martinussen, I., Nilsen, G., Svenson, L., Junttila, O., Rapp, K. (2004). *In vitro* propagation of cloudberry (*Rubus chamaemorus*). *Plant Cell, Tiss. Org. Cult., 78,* 43-49.

Mayer-Miebach, E., Adamiuk, M., Behsnilian, D. (2008). Research project Dietary procyanidins – From a better understanding of human health effects to functionalised foods. Process engineering to improve procyanidin stability and extractability Internal Report.

McKay, S.A.(2008). Demand increasing for aronia and elderberry in North America. Available at http://www.fruit. cornell.edu/Berries/specialtyfru%20pdf/aroniaeldeberry.pdf. (Reprinted from: New York Berry News, Vol. 3, No. 11, March 17, 2004).

Murashige, T., Skoog, F. (1962). A revised medium for rapid growth and bioassays with tobacco tissue cultures. *Physiol. Plant., 15 (3),* 473-497.

Oszmianski, J., Wojdylo, A. (2005). *Aronia melanocarpa*phenolics and their antioxidant activity. *Eur. Food Res. Technol., 221,* 809-813.

Popescu, A., Isac, V. (2000). High frequency shoot regeneration from leaf-derived callus in raspberry (*Rubus idaeus* L.). *Acta Hort., 538,* 667-670.

Ruzic, D., Lazic, T. (2006). Micropropagation as means of rapid multiplication of newly developed blackberry and black currant cultivars. *Agriculturae Conspectus Scientificus, 71,* 149-153.

Sedlák, J., Paprštein, F. (2012). *In vitro* establishment and proliferation of red currant cultivars. *Hort. Sci. (Prague), 39(1),* 21-25.

Seeram, N.P., Aviram, M., Zhang, Y., Henning, S.M., Feng, L., Dreher, M. *et al.* (2008). Comparison of antioxidant potency of commonly consumed polyphenol-rich beverages in the United States. *J. Agric. Food Chem., 56,* 1415-1422.

Shtereva, L., Vassilevska-Ivanova, R., Karceva, T., Kraptchev, B., 2014. Micropropagation of six *Paulownia* genotypes through tissue culture. *J. Central Eur. Agric., 15(4),* 147-156.

*Corresponding author, E-mail address: ancasutan@yahoo.com

Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521

Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

Simeonov, S.B., Botushanov, N.P., Karahanian, E.B., Pavlova, M.B., Husianitis, H.K., Troev, D.M., (2002). Effects of *Aronia melanocarpa*juice as part of the dietary regimen in patients with diabetes mellitus. *Folia Med. (Plovdiv), 44*, 20-23.

Strigl, A.W., Leitner, E., Pfannhauser, W. (1995). Die schwarze Apfelbeere (*Aronia melanocarpa*) als natürliche Farbstoffquelle. *Deutsch. Lebensmitt Rundsch., 91*, 177-180.

Şuțan, N.A.,Popescu, A., Isac, V. (2010). *In vitro* culture medium and explant type effect on callogenesis and shoot regeneration in two genotypes of ornamental strawberry. *Rom. Biotech. Lett.,15(2),* Suppl., 12-18.

Tanaka, T., Tanaka, A. (2001). Chemical components and characteristics of black chokeberry. *J. Jpn. Soc. Food Sci. Technol., 48*, 606-610.

Valcheva-Kuzmanova, S., Borisova, P., Galunska, B., Krasnaliev, I., Belcheva, A.(2004). Hepatoprotective effect of the natural fruit juice from *Aronia melanocarpa* on carbon tetrachloride-induced acute liver damage in rats. *Exp. Toxicol. Pathol., 56*, 195-201.

Wainwright, H., Flegmann, A.W. (1986). Studies on the micropropagation of *Ribes* species. *Acta Hort., 183*, 315-321.

Wawer, I., Wolniak, M., Paradowska, K. (2006). Solid state NMR study of dietary fiber powders from *Aronia*, bilberry, black currant and apple. *Solid State Nucl. Magn. Reson., 30*, 106-113.

Wu, X.L., Gu, L.W., Prior, R.L., McKay, S. (2004).Characterization of anthocyanins and proanthocyanidins in some cultivars of *Ribes*, *Aronia*, and *Sambucus* and their antioxidant capacity. *J. Agric. Food Chem., 52*, 7846-7856.

*Corresponding author, E-mail address: ancasutan@yahoo.com