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# Effects of Fall Applications of Urea in Order to Improve Fruit Sizes, Weight and Buds Cold Hardiness in Sweet Cherry

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**Abstract.** The influence of treatments with urea, in quantity of 10 litres per hectare each time, on four cultivars of sweet cherry under the climatic conditions of Cluj-Napoca, Romania, in 2010-2011, was studied. Measurements on length of shoots, leaf area, trunk cross sectional area, yield and fruits weight were made. There were no differences regarding fruit firmness compared to untreated control. Better results using two treatments with urea were obtained. Treatment with, urea in tree variants were made: V1 - control which has no treatment received with urea; V2 - in which one treatment of urea in quantity of 10 litres per hectare in the autumn after fruits harvest but before leaves fall; V3, received two sprinklings with urea in quantity of 10 litres per hectare; one of them in the autumn after fruit harvest but before leaves fall and the second in the spring. Measurements were made on length of shoots, leaf area, trunk cross sectional area, yield and fruits weight. Both treatments with urea increased the length of shoots, leaf area, trunk cross sectional area, yield and fruits weight. The best results in case of V3 – one treatment with urea in quantity of 10 litres per hectare in the autumn after fruits harvest but before leaves fall plus the second one in the spring before buds burst were performed.

**Keywords**: cherries, foliar fertilization, growth, yield, fruit set

## INTRODUCTION

Sweet cherry trees accumulate nitrogen (N) before leaf fall, store them over winter, and remobilize them for initial growth and development the following spring.

Reserve N is present in the form of proteins or free amino acids. Non-structural carbohydrates include starch and soluble sugars (sucrose, glucose, fructose and sorbitol). Both reserve N and carbohydrates play an essential role in supporting new growth by providing structural components and energy (Cheng *et al*., 2004).

Although N storage determines early spring growth in trees, the usefulness of autumn N supply remains unclear as N uptake decreases in autumn, but could be restored earlier in spring to compensate for low N cycling (Jordan *et al*., 2012).

The use of N reserves for new growth in the spring is especially important for sweet cherry (*Prunus avium* L.), for which new shoot and fruit growth is concomitant and fruit development occurs during a relatively short bloom-to-ripening period (Cowgill, 2012; Ouzounis and Lang, 2011; Wocior *et al*., 2011).

Glozer and Grant (2006) found that chemical applications of urea tended to advance bloom and that the most effective timings were consistent, based on chill portion accumulation and the Dynamic Model. In one of two years, chemical treatments tended to decrease floral bud death and increase fruit set when compared to hand defoliation and untreated trees.

The purpose of this study is to evaluate the influence of urea application on growth and fruiting of some sweet cherry cultivars in Cluj-Napoca County, Romania.

## MATERIALS AND METHODS

The experimental unit was located at SC Agroindustriala SA Cluj-Napoca in 2011-2012, in a sweet cherry orchard established in 1996. Planting distance was 5 m between the rows and 4 m between the trees per row, respectively, thus resulting a density of 500 trees per hectare. In order to study the influence of urea foliar treatments upon growth and fruiting of sweet cherry, two variants of using urea compared as to untreated variant as control were set. The biological material was represented by four varieties of cherry, as follows: 'Stella', 'Van', 'Rubin', 'Boambe de Cotnari', grafted on mahaleb. The trees were trained as leader pyramid. Measurements were made on length of shoots, leaf area, trunk cross sectional area, yield and fruits weight.

The experiment was bifactorial with factor A - the cultivar with four graduations, respectively factor B - the treatment with three graduation: graduation 1- control which has no received treatments with urea; graduation 2 in which one treatment of urea in quantity of 10 litres per hectare were performed; graduation 3 received two sprinklings with urea in quantity of 10 litres per hectare one of them in the autumn after fruits harvest but before leaves fall and the second in the spring. Thus, 12 experimental variants resulted. Each experimental variant had three replicates. The results were computed using Duncan's Multiple Range procedures.

## RESULTS AND DISCUSSIONS

Intensity of shoots growth in the early stages of vegetation is a very important physiological phenomenon. The leaves situated on the young shoots are necessary in assimilation and the shoots themselves will be the future bearing branches for the next yielding year. All life of the trees depends on shoots growth.

The results displayed in Tab. 1 prove definite influence of urea application upon shoot length in cherry.

Tab. 1

The influence of urea applications and the cultivar upon average shoots length (cm) of the cherry trees, Cluj-Napoca, Romania, 2010-2011

| Cultivar/urea application variant | Control (untreated) | One treatment of urea | Two treatments of urea | Mean of cultivar |
|---|---|---|---|---|
| 'Stella' | $42.47^{g}$ | $48.27^{e}$ | $63.63^{a}$ | $51.46^{A}$ |
| 'Van' | $37.53^{h}$ | $42.47^{g}$ | $44.60^{f}$ | $41.53^{C}$ |
| 'Rubin' | $38.50^{h}$ | $45.53^{f}$ | $51.27^{d}$ | $45.10^{B}$ |
| 'Boambe de Cotnari' | $45.60^{f}$ | $53.80^{c}$ | $58.93^{b}$ | $52.78^{A}$ |
| Mean of treatment | $41.03^{O}$ | $47.52^{N}$ | $54.61^{M}$ | - |

Note: Different letters between cultivars denote significant differences (Duncan test, $p < 0.05$). LSD 5% cvs 1.39-1.51; LSD 5% treatment 1.20-1.28; LSD 5% interact. 2.41-2.88.

Regardless of cultivar, differences statistically assured between variants were registered. The longest shoots in the variant with two treatment with urea were recorded (54.61 cm), followed by the variant receiving one treatment of urea (47.52 cm).

Regarding the influence of cultivar regardless of the treatment with urea, there are differences between cultivars, some of them statistically assured some not. The longest shoots 'Boambe de Cotnari' (52.78 cm) recorded, followed by 'Stella' (51.46 cm) without differences statistically assured. 'Van' and 'Rubin' cherry cultivars behaved differently regarding the average length of shoots having differences statistically assured between them and the others two cultivars.

Data from the table show the combined influence of the two experimental factors. The longest shoots in 'Stella' cultivar receiving two treatments with urea were registered and the shortest in 'Rubin' found in the untreated variant.

Nitrogen application definitely increases the flowering spur N going into winter and can improve spur leaf size the next spring. This translates into larger fruit size (Cowgill, 2012). Ouzounis and Lang (2011) showed that spur leaf size in the spring was associated with storage N levels; fall foliar urea treatments increased spur leaf area by up to 24% in sweet cherry.

Tab. 2 introduces date regarding the influence of urea applications and the cultivar upon average leaf area on the sweet cherry trees. Data obtained by the above authors were confirmed by this experiment. Urea application had a strong influence on the leaf area with differences statistically assured between all three variants.

Regardless the cultivar, the biggest leaf area in variant with two treatment with urea were obtained (69.36 $m^2$) followed by one treatment of urea variant (56.83 $cm^2$). The differences statistically assured of the two variants with urea applications compared as to the control demonstrates the effectiveness of urea application on growth of sweet cherry leaves.

Tab. 2

The influence of urea applications and the cultivar upon average leaf area ($cm^2$) of the cherry trees, Cluj-Napoca, Romania, 2010-2011

| Cultivar /urea application variant | Control (untreated) | One treatment with urea | Two treatments with urea | Mean cultivar |
|---|---|---|---|---|
| 'Stella' | $52.5^{i}$ | $57.5^{f}$ | $67.3^{c}$ | $59.1^{B}$ |
| 'Van' | $46.2^{l}$ | $51.4^{j}$ | $66.4^{d}$ | $54.6^{D}$ |
| 'Rubin' | $48.1^{k}$ | $55.4^{g}$ | $68.4^{b}$ | $57.3^{C}$ |
| 'Boambe de Cotnari' | $54.3^{h}$ | $63.1^{e}$ | $75.4^{a}$ | $64.3^{A}$ |
| Mean of treatment | $50.3^{O}$ | $56.8^{N}$ | $69.4^{M}$ | - |

Note: Different letters between cultivars denote significant differences (Duncan test, $p < 0.05$). LSD5% cvs 0.77-0.84; LSD5% cvs 0.67-.71; LSD5% cvs 1.34-1.60

Data from the last column of the table show that between the cultivars there are differences statistically assured regarding the leaves area. These differences could be explained only from a genetic point of view. The largest leaf area in 'Boambe de Cotnari' was obtained (64.3 $cm^2$) and the smallest in 'Van' (54.6 $cm^2$).

Data from the table show the combined influence of two experimental factors. The biggest average leaf area with 'Boambe de Cotnari' and two urea treatments was registered and the smallest with 'Van' in untreated variant.

Wocior *et al.* (2011) reported increasing trend in trunk cross-sectional area, canopy volume, shoots length, yield, after urea aplication on 'Łutówka' sour cherry cultivar. Analyzing data from Table 3, one can see that the treatments with urea influenced obviously the surface of the trunk section. The biggest average trunk cross sectional area with the two treatment of urea were obtained (430.70 $cm^2$), followed by one treatment of urea (417.39 $cm^2$). The smallest trunk cross sectional area was registered with untreated variant.

Data from the last column of the table show that between the cultivars there are differences statistically assured regarding the trunk cross sectional area. These differences could be explains only from genetically point of view. The largest trunk section in 'Boambe de Cotnari' (472.42 $cm^2$) was obtained and the smallest in 'Rubin' (357.62 $cm^2$).

Data inside the table show the combined influence of two experimental factors. The biggest average trunk cross sectional area with 'Boambe de Cotnari' with two treatments with urea was registered and the smallest with 'Van' in untreated variant.

Tab. 3

The influence of urea applications and the cultivar upon trunk cross sectional area ($cm^2$) of the cherry trees, Cluj-Napoca, Romania, 2010-2011

| Cultivar/ urea application variant | Control – untreated | One treatment with urea | Two treatments with urea | Mean cultivar |
|---|---|---|---|---|
| 'Stella' | $396.38^{d}$ | $439.69^{c}$ | $469.92^{ba}$ | $435.33^{C}$ |
| 'Van' | $335.98^{f}$ | $375.35^{e}$ | $403.32^{d}$ | $371.55^{A}$ |
| 'Rubin' | $357.96^{e}$ | $366.50^{e}$ | $348.41^{f}$ | $357.62^{B}$ |
| 'Boambe de Cotnari' | $428.09^{c}$ | $488.03^{a}$ | $501.15^{a}$ | $472.42^{A}$ |
| Mean of treatment | $379.60^{N}$ | $417.39^{M}$ | $430.70^{M}$ | - |

Note: Different letters between cultivars denote significant differences (Duncan test, $p < 0.05$). LSD5% cvs 18.35-19.89; LSD5% treatment 15.9-16.84; LSD5% interact. 31.79-38.02

Urea applications had a strongly influence also upon canopy volume of the trees located in this experiment (Tab. 4).

Regardless the cultivar the biggest canopy volume with two treatment with urea was registered (16.38 $m^3$), followed by the variant with one treatment of urea (15.62 $m^3$). The smallest canopy volume in untreated variant was obtained. The differences statistically assured between all three variants prove obviously the influence of urea treatments on growth of crown volume.

Data from the last column of the table show that between the cultivars there are differences statistically assured regarding the trunk cross sectional area. These differences could be explained only from a genetic point of view.

Tab. 4

The influence of urea applications and the cultivar upon canopy volume ($m^3$) of the cherry trees, Cluj-Napoca, Romania, 2010-2011

| Cultivar/ urea application variant | Control (untreated) | One treatment with urea | Two treatments with urea | Mean cultivar |
|---|---|---|---|---|
| 'Stella' | $15.13^{c}$ | $16.14^{b}$ | $17.36^{a}$ | $16.21^{B}$ |
| 'Van' | $12.36^{e}$ | $13.67^{d}$ | $14.13^{c}$ | $13.39^{D}$ |
| 'Rubin' | $13.25^{d}$ | $15.10^{c}$ | $16.00^{b}$ | $14.78^{C}$ |
| 'Boambe de Cotnari' | $16.14^{b}$ | $17.57^{a}$ | $18.02^{a}$ | $17.24^{A}$ |
| Mean of treatment | $14.22^{O}$ | $15.62^{N}$ | $16.38^{M}$ | - |

Note: Different letters between cultivars denote significant differences (Duncan test, $p < 0.05$). LSD5% cvs 0.93-1.01; LSD5% treatment 0.80-0.85; LSD5% interact. 1.61-1.92.

Table 5 introduces data regarding the influence of urea applications and the cultivar upon yield of cherry. Regarding data of the last row one can see that regardless the cultivar there are differences statistically assured between all three variants. The largest yield values were obtained following the application of the third prescription (10781.67 kg/ha) followed by the second (9380 kg/ha) and the first variant (7440 kg/ha).

Data from the table show the combined influence of the two experimental factors. The biggest yield was given by 'Boambe de Cotnari' cultivar receiving two treatments with urea and the smallest 'Stella' found in the untreated variant. These differences could be explained only from a genetic point of view.

Tab. 5

The influence of urea applications and the cultivar upon yield of cherry (kg/ha), Cluj-Napoca, Romania, 2010-2011

| Cultivar/urea application variant | Control (untreated) | One treatment with urea | Two treatments with urea | Mean cultivar |
|---|---|---|---|---|
| ‘Stella’ | $6400.00^{i}$ | $8396.67^{f}$ | $10493.33^{c}$ | $8430.00^{D}$ |
| ‘Van’ | $7333.33^{h}$ | $9863.33^{d}$ | $10740.00^{b}$ | $9312.22^{C}$ |
| ‘Rubin’ | $7786.67^{g}$ | $9026.67^{e}$ | $10366.67^{c}$ | $9060.00^{B}$ |
| ‘Boambe de Cotnari’ | $8240.00^{f}$ | $10233.33^{c}$ | $11526.67^{a}$ | $10000.00^{A}$ |
| Mean of treatment | $7440.00^{O}$ | $9380.00^{N}$ | $10781.67^{M}$ | - |

Note: Different letters between cultivars denote significant differences (Duncan test, $p < 0.05$). LSD5% cvs 165.84-179.76; LSD5% treatment 143.62- 152.16; LSD5% interact. 287.24-343.49.

The start given by urea fall and spring fertilization had beneficial effects on fruit growth in weight.

Looking through the data from the last row of the table one can observe that there are differences statistically assured between all three variants, regardless the cultivar. The biggest fruit weight in the variant treatment with urea was recorded (7.51 g) followed by the variant with one treatment with urea (7.18 g). The lowest average weight of fruits was registered in the untreated variant.

Data from the last column of the table show that between the ‘Stella’ and ‘Van’ cultivars there are differences statistically assured. Looking at the data from the table, one can say that the biggest fruit weight in ‘Stella’ (7.97 g) with two treatments with urea was obtained and the smallest in ‘Van’ with untreated control (6.57 g).

Tab. 6

The influence of urea applications and the cultivar upon average fruit weight (g) of the cherry trees, Cluj-Napoca, Romania, 2010-2011

| Cultivar/ urea application variant | Control – untreated | One treatment with urea | Two treatments with urea | Mean cultivar |
|---|---|---|---|---|
| ‘Stella’ | 7.23 | 7.40 | 7.97 | 7.53A |
| ‘Van’ | 6.57 | 6.67 | 7.03 | 6.76C |
| ‘Rubin’ | 7.10 | 7.30 | 7.43 | 7.28B |
| ‘Boambe de Cotnari’ | 7.10 | 7.37 | 7.60 | 7.36B |
| Mean of treatment | 7.00 | 7.18 | 7.51 | - |

Note: Different letters between cultivars denote significant differences (Duncan test, $p < 0.05$). LSD5% cvs 0.06-0.07; LSD5% treatment 0.06-0.06; LSD5% interact. 0.11-0.13.

Ouzounis and Lang (2011) reported that during fall, total N in leaves decreased by up to 51% [dry weight (DW)] and increased in canopy organs such as flower spurs by up to 27% (DW). The N concentration in flower spurs increased further in spring by up to 150% (DW). Fall foliar applications of urea increased storage N levels in flowering spurs (up to 40%), shoot tips (up to 20%), and bark (up to 29%). Premature defoliation decreased storage N in these tissues by up to 30%. Foliar urea applications mostly increased flower spur N levels when applied in late summer to early fall.

Looking at the data of this paper one can observed a lot of benefits of urea fall applications such as: increasing length of shoots, leaves area, canopy volume, and yield of sweet cherry.

## CONCLUSION

The use of N reserves for new growth in the spring is especially important for sweet cherry. Since the early stages of vegetation in cherry runs from last year's accumulation urea fall and early spring, application is very useful for sweet cherry. A good nitrogen accumulation in the buds creates the opportunity for better evolution of the trees in the entire vegetation period. Two applications with 10 litres of urea first in the autumn after fruits harvest but, before leaves fall and the second in the spring before buds burst, proved to be the best formula. Two applications with 10 litres of urea increased the length of shoots, leaf area, trunk cross sectional area, yield and fruits weight in sweet cherry.

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