IMPACT OF MICRONIZED CALCITE ON THE YIELD AND QUALITY OF HOPS (*Humulus lupulus* L.)

Barbara ČEH[5]

UDC / UDK 633.791 : 631.559 : 631.82 (045)
original scientific article / izvirni znanstveni članek
arrived / prispelo: 05. 10. 2010
accepted / sprejeto: 30. 11. 2010

Abstract

A result of a special technological process of mechanical milling of calcite and collision at high frequency are particles of micro and submicro sizes (0.2-50 μm) with highly increased specific surface. These energized particles can be sprayed finely to the leaves and can be taken in plants directly through stomata and as a result a reduced water requirement of plants is expected because CO_2 is converted from calcite inside the leaves. Other elements that micronized calcite contains should have positive impact on plant physiology. In a two year investigation with the use of micronized calcite spraying of hops cv. Aurora it was indicated that it has positive impact on the yield in a season with more frequent stress conditions (high temperatures oscillations, lack of precipitation), but in a season with average weather conditions and enough precipitation its positive impact was not detected. In both investigated seasons it was shown that N, P, K fertilization can't be avoided, even if spraying by micronized calcite is performed, if the same yield as at conventional production wants to be reached.

Key words: hops, *Humulus lupulus* L., fertilization, micronized calcite, yield, alpha acids

VPLIV MIKRONIZIRANEGA KALCITA NA PRIDELEK IN KAKOVOST HMELJA (*Humulus lupulus* L.)

Izvleček

Rezultat posebne tehnologije mehanskega mletja kalcita in kolizije delcev pri visokih frekvencah so delci mikro in submikro velikosti (0.2-50 μm) z zelo povečano specifično površino. Delci, raztopljeni v vodi, se pri pršenju fino nanesejo na liste rastline in prehajajo v liste neposredno skozi reže, zato naj bi se zaradi CO_2, v katerega se pretvori proizvod znotraj rastline, zmanjšala potreba po vodi. Druga hranila, ki jih proizvod vsebuje, naj bi pozitivno vplivala na fiziologijo rastline. V dvoletni raziskavi s pršenjem hmelja z mikroniziranim kalcitom med rastno sezono se je nakazal pozitiven učinek (razlike sicer niso bile statistično značilne) tega ukrepa na pridelek hmelja v sezoni z več stresnimi situacijami (velika temperaturna nihanja, malo padavin), ne pa v sezoni s povprečnimi vremenskimi razmerami in večjo količino padavin. V obeh sezonah se je nakazalo, da če želimo doseči enak pridelek kot

[5] PhD, Slovenian Institute of Hop Research and Brewing, Cesta Žalskega tabora 2, 3310 Žalec, Slovenia, e-mail: barbara.ceh@ihps.si

v konvencionalni pridelavi, se kljub pršenju hmelja z mikroniziranim kalcitom gnojenju z N, P, K gnojili ne moremo izogniti.

Ključne besede: hmelj, *Humulus lupulus* L., gnojenje, prehrana rastlin, mikroniziran kalcit, pridelek, alfa kisline

1 INTRODUCTION

Calcite milled in dry or wet system in micronized size can be used in paper, plastic, paint, cable, construction, adhesive, ceramic, carpet,… sectors and also as food additive in biscuits, breads and chewing gums. Due to its chemical purity, colour and low price, it is used as a source of calcium [8]. The result of a special technological process of mechanical milling of calcite and collision at high frequency are particles of micro and submicro sizes (0.2-50 μm**)** with highly increased specific surface. Micronized calcite (MC) is 100 % natural product from limestone deposits. It contains $CaCO_3$ (around 94 %) and other nutrients (MgO, SiO_2, Fe_2O_3,...) with regard to its natural origin. For plant nutrition it is used in a 0.3-0.5 % water suspension for spraying [4,5,6]. These energized particles can be sprayed finely to the leaves and can be taken into plants directly through stomata and as a result a reduced water requirement of plants is expected because CO_2 is converted from calcite inside the leaves. Other elements that the product contains should impact positive on plant physiology.

2 MATERIAL AND METHODS

2.1 Experimental layout and realization

Field experiment was conducted at the experimental field of Slovenian Institute of Hop Research and Brewing in the season 2007 and continued at the same plots in 2008 as a random block trial in three replications. The size of plots was 380 m^2, so the whole size under the experiment was approximately 4500 m^2. There were three treatments investigated:

K: Control treatment; conventional fertilization by phosphorus (P) and potassium (K) according to the soil analyse, conventional fertilization by nitrogen (N) (50+70+50 kg/ha N; 20th May, 10th June and 10th July respectively), no foliar fertilizers, spraying by insecticides and fungicides (PPP) according to the spraying program*.

K+MC: Conventional fertilization by P and K according to the soil analyse, conventional fertilization by N, spraying by PPP according to the spraying program, after each spraying by PPP spraying by MC (3 kg/ha) (3-times in season 2007, 5-times in season 2008).

MC+PPP: No fertilization by P, K and N, spraying by PPP according to the spraying program, after each spraying by PPP spraying by MC (3 kg/ha) (3-times in season 2007, 5-times in season 2008).

*In 2007: 12th June insecticides Kohinor and Vertimec and fungicide Cuprablau, 2nd July Cuprablau, 18th July insecticides. In 2008: 11th June Cuprablau and Confidor, 3rd July Delan,

Confidor and Nisurun, 17th July Cuprablau, 26th July Vertimec, Folpan and Silvet, 12th August Cuprablau and Pepelin.

The rest of the agrotechnique was the same for all plots and performed in the terms of good agricultural practise. Fertilization by nitrogen in the form of KAN was performed manually, spraying by PPP and by MC was performed manually when hop plants were still small, but when they reached the top of the trellis, spraying was performed by machinery.

Measurements of plant growth and detection of growth stages were detected once to twice a week. Soil sampling for quick soil test Nmin (nitrate and ammonium) [7] was performed on 20th May (before 1st N fertilization at control), on 5th July (before 3rd N fertilization at control) and after harvest. Before harvest border rows of hop plants were removed, the inner two rows were harvested plot by plot and evaluated. Plot size was measured, number of plants and number of strings per plots were counted. Yield per plots was weighted, samples of cones were taken and delivered to the laboratory of Slovenian Institute of Hop Research and Brewing.

2.2 Chemical analyses

Moisture content in hop cones was detected according to EBC Analytica (1998) [1], alpha acid content according to EBC Analytica (2000) [2] in 2007 and 2008, in 2008 also nitrate content in hop cones was analysed (according to DIN/EN (1998) [3]).

2.3 Processing of statistical data

Results were statistically processed by the computer programs Excel and Statgraphics, differences among treatments were detected by Duncan multiple range test ($p<0.05$).

2.4 Weather and soil conditions

There were above average temperatures in the season of 2007. Extremely high temperatures were in the second half of July when maximum daily temperatures exceeded 35ºC. There were also high temperatures oscillations; temperatures raised and decreased in a short time period even for 10°C. Average temperature from the beginning of April to the end of August was 18.2ºC; for almost 2 degrees higher compared to the long term average. April was warmer for 3.2ºC, May for 1.9ºC, the second decade of June for 4.4ºC and August for 0.3ºC compared to the long term average. There was 473 mm of precipitation in the season of 2007; 116 mm less compared to the long term average. On the other hand precipitations were not equally disposed with regard to location, time and quantity.

In the season 2008 there was 713 mm precipitation, what means 124 mm more than in a long term average. Precipitation was locally and timely not uniform disposed; there were lots of storms with hail which appeared already in May. In the period from June to August there was 83 % of all seasonal precipitation. There was only 47 mm precipitation in May and as much as 228 mm in June. Average temperature from the beginning of April to the end of August was 16.4°C, what is by 1°C more compared to the long term average. April was warmer by 0.7°C, May by 1.6°C. In June there were very variable temperatures; the second decade was by 1.2°C colder compared to the long term average, minimum daily temperature was 9.9°C.

But, in the last decade of June, high temperatures were detected. In the most of the days daily temperature exceeded 30^0C, average decade temperature was by 4.6^0C higher compared to the long term average. July and August were comparable to the long term average.

Soil of the experimental field is sandy clay loam, pH value at the conduction of the experiment was 5.8, phosphorus supply was excessive, potassium supply was adequate (Table 1).

Table 1: Soil analyze results (AL method) at the conduction of the experiment
Preglednica 1: Rezultati analize tal (AL metoda) pred postavitvijo poskusa

pH in KCl	pH in Ca-acetate	P_2O_5* mg/100 g soil	K_2O* mg/100 g soil
5.8	6.5	36.0	24.9

3 RESULTS AND DISCUSSION

3.1 Plant available nitrogen in soil

In the first investigated year (2007) there was around 80 kg/ha plant available N in the upper layer of soil (0-25 cm) in May (Table 2).

At the end of July 2007 there were differences among treatments, as expected. At treatments K and K+MC there was higher quantity of plant available N in soil (142-150 kg/ha N) compared to the treatment MC+PPP (49 kg/ha N), where no N fertilization was included. At treatments where N fertilization was included (K and K+MC) plant available N quantity in soil was increased by around 55 kg/ha from May to the end of July, although plants absorbed N in that time, too. At the treatment MC+PPP plant available N quantity was lower by around 30 kg/ha N.

After harvest in 2007 differences among treatments in quantity of plant available N in the upper layer of the soil were lower compared to the end of July; it was decreased by around 50 kg/ha at treatments K and K+MC and stayed almost at the same level at treatment MC+PPP (Table 2). At treatments K and K+MC quantity of plant available N in soil was relatively high for that time.

In May 2008 there was comparable quantity of plant available N in the upper layer of the soil among treatments (17-24 kg/ha N; Table 2).

In the first days of July 2008, before the third N fertilization at treatments K and K+MC, there was a bit higher quantity of N in soil compared to quantity in May; 42-66 kg/ha N. Compared to the first sampling in May there was higher quantity of plant available N in soil at all treatments, also treatments with no N fertilization, what points to the good mineralisation of N from soil organic matter in that time. As expected there was lower quantity of plant available N at treatment MC+PPP where no N was fertilized, compared to treatments K and K+MC where 120 kg/ha N was fertilized in May and June.

Table 2: Quantity of plant available N in the upper layer of soil according to Nmin analyse in 2007 and 2008 with regard to treatment and sampling date (kg/ha)
Preglednica 2: Vsebnost rastlinam dostopnega dušika (Nmin) v zgornjem sloju tal glede na obravnavanje in datum vzorčenja v letih 2007 in 2008

		2007			2008		
Date of sampling	Treatment	NO_3–N (kg/ha)	NH_4–N (kg/ha)	NO_3–N + NH_4–N (kg/ha)	NO_3 – N (kg/ha)	NH_4–N (kg/ha)	NO_3–N + NH_4–N (kg/ha)
20th May	K	71	25	96	16	5	21
	K+MC	71	12	83	20	4	24
	MC + PPP	67	12	79	12	5	17
31st July in 2007, 5th July in 2008	K	119	31	150	51	15	66
	K+ MC	123	19	142	40	18	58
	MC + PPP	40	10	49	28	14	42
After harvest	K	83	11	94	36	11	47
	K+ MC	83	12	95	28	8	36
	MC + PPP	32	10	41	16	10	26

In the soil of all treatments there was not more than 50 kg/ha of plant available N after harvest (Table 2). With regard that the same quantity of mineral N was fertilized at treatments K and K+MC and that there was lower quantity of plant available N in the soil of the treatment K+MC, a bit higher absorption of N at plants of the treatment K+MC is assumed.

3.2 Plant growth and development

In 2007 plants at the control treatment (K) grew the slowest; the fastest grew plants at treatments K+MC. But at the end of June plants of all treatments reached the top of the construction. Flowering started a week sooner at treatments K and K+MC compared to MC+PPP, while flowering ended approximately at the same time at all treatments in 2007.

In 2008 there were no important differences among treatments.

3.3 Yield

Although differences between treatments K and K+MC could not be statistically confirmed, in drier season with high temperatures oscillations (2007) higher yield was indicated at treatment K+MC (Table 3) what suggests the conclusion that spraying with MC is more appropriate in that kind of season (stress conditions). Significantly lower yield was detected at the treatment with no N, P, K fertilization (MC+PPP).

In the season with above average precipitation quantity, especially in June and July (2008), spraying by MC did not impact the yield of hops significantly, too; there were no significant difference among all investigated treatments. In both seasons it was shown that N, P, K fertilization can't be avoided, even if spraying by MC is performed, if the same yield as at K wants to be reached.

Table 3: Yield of cones (kg/ha DM, kg/plant DM), alpha acids content (% DM) and alpha acids yield (kg/ha) in the experiment in 2007 and 2008
Preglednica 3: Pridelek (kg/ha suhe snovi, kg/rastlino), vsebnost alfa kislin (% v suhi snovi) in pridelek alfa kislin (kg/ha) v poskusu v letu 2007 in 2008

	Yield of cones (kg/ha DM)		Yield of cones (kg/plant DM)		Alpha acid content (% DM)		Alpha acid yield (kg/ha)	
	2007	2008	2007	2008	2007	2008	2007	2008
K	1301 *b**	1780 *a*	0,43 *bc*	0,61 *a*	6,9 *a*	10,3 *a*	90 *b*	183 *a*
K+MC	1394 *b*	1637 *a*	0,49 *c*	0,58 *a*	6,9 *a*	10,6 *a*	96 *b*	174 *a*
MC+PPP	1067 *a*	1452 *a*	0,36 *ab*	0,52 *a*	6,4 *b*	10,9 *a*	68 *a*	159 *a*

* The same letter in the column indicates that there is no significant difference between treatments (Duncan multiple range test, $p<0.07$).

3.4 Alpha acid content and alpha acid yield

There was significantly lower alpha acids content at treatment MC+PPP compared to the other two investigated treatments in 2007. In 2008 there was no significant difference in alpha acid content among treatments (Table 3). The characteristic of the season 2007 compared to 2008 was that hop cones contained less alpha acids.

In the yield of alpha acids the same results were obtained as in the case of the yield of cones. N fertilization was indicated to impact positively on the yield of alpha acids, although differences among treatments could not be statistically confirmed (differences among blocks were too high).

3.5 Nitrate content

In 2008 nitrate content in hop cones at the technological maturity was analyzed with regard to treatment. The highest nitrate content was indicated at K and the lowest at the treatment where no N fertilization was carried out (MC+PPP) (Table 4).

Table 4: Nitrate content in hop cones with regard to treatment in 2008
Preglednica 4: Vsebnost nitratov v storžkih glede na obravnavanje v letu 2008

	Nitrate content (mg/100 g DM)
K	1253
K+MC	871
MC+PPP	494

Spraying by MC was indicated to lower nitrate content in hop cones. But, because investigation of nitrate content in hop cones was not performed by plots but only by treatments, statistic could not be done to confirm these findings, so these starting points are left for the future investigations.

4 CONCLUSIONS

In a two year investigation it was indicated that spraying by MC has positive impact on the yield of hops cv. Aurora and its quality in a season with more frequent stress conditions (high temperatures oscillations, lack of precipitation), but in a season with more average weather conditions and enough precipitation positive impact was not detected. In both investigated seasons it was shown that N, P, K fertilization can't be avoided, even if spraying by MC is performed, if the same yield as at K wants to be reached.

5 LITERATURE

1. Analytica EBC (1998): Method for moisture detection, 7.2
2. Analytica EBC (2000): Method KVH-TE, 7.4
3. DIN/EN (1998): Bestimung des Nitrat- und /oder Nitrite gehaltes EN 12014-7:1998
4. Fitolife (2009): http://www.fitolife.com.hr/, 22nd January 2009.
5. Herbagreen, 2010: http://www.herbagreen.si/
6. Megagreen, 2010: http://greengrasssales.com/megagreen/
7. Sušin, J., Kmecl, V. 2000. Navodila za uporabo RQ-flexa. Kmetijski inštitut Slovenije, Ljubljana: 14 s.
8. Dogan, 2010: http://www.doganltd.com.tr/usage.htm