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Effect of CCC on Carbohydrate and Nitrogen Metabolism in Ripening Wheat Kernels

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The morphological variations of wheat plants caused by CCC treatment are well known. As the nitrogen supply by fertilization to these shortened plants is at least the same or even higher than to untreated controls, one could imagine that also the ripening kernels will be affected by CCC treatment.

Therefore, the aim of our experiments was to examine the influence of CCC treatment on total nitrogen uptake of plants, dislocation of carbohydrate and portein fractions in different stages of ripening combined with destinations of CCC residues in fully mature kernels. The influence of CCC was seperated from that of nitrogen gradation.

CCC is a quaternary ammonium compound, related to cholin and betain. (Fig. 1).

This compound will be taken up quickly by plants and accumulate in their shoots, later on it will be decomposed enzymatically in the leaves, excreted by guttation and also transported back to the roots.

1. Dry matter production of wheat under the influence of CCC treatment is partly unaffected but mostly a little reduced by this shortening effect. In field trails we determined for a few years the nitrogen in wheat plants (Opal) in different stages of vegetative development and calculated the total nitrogen uptake (Table 1).

In all three stages of development, the nitrogen content of CCC-treated plants is definitely higher than in not-lodged controls. These differences in content combined with more or less higher dry matter production in all cases lead to a much higher nitrogen uptake especially in later stages of vegetative development of wheat plants.

2. Now the next question was : How is the influence of CCC on the ripening process of kernels ?

For this purpose green, yellow and fully-mature kernels were collected, deep-frozen and analyzed.

The stage of ripening can be defined by the interrelationship of starch, mono-and disaccharides, soluble nitrogen compounds and different protein fractions. These criteria determine whether the ripening process of wheat kernels would be delayed by CCC treatment.

Fig. 1 Chemical structure of Chlorcholinchloria (CCC) and related substances

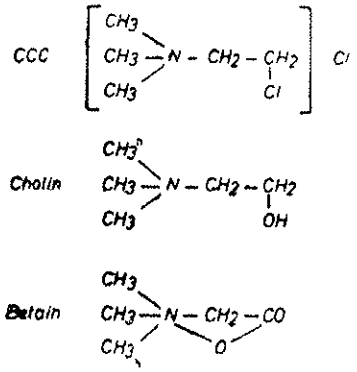


TABLE 1. Nitrogen content and nitrogen uptake of wheat plants. (Fertilization : 120 kg N/ha).

Criteria	CCC L/ha	Stage of development		
		Sprouting	Shooting ears	Immediately before blossom
N-content . .	0	3.44	1.95	1.30
(% in dry . .	1.25	3.92	2.20	1.62
matter) . . .	3.75	3.73	2.38	1.83
N-uptake . .	0	14.1	19.1	21.5
(g/50m²) . . .	1.25	15.3	21.6	25.3
	3.75	15.3	28.6	24.0

a) *Carbohydrate metabolism*

Early stages are charactarized by high content of total sugars and a low content of starch. During the ripening process of wheat kernels, a definite decrease of monosaccharides from 3 to about 1%, total sugars from 15 to about 4% and a steeply-rising starch content from 60 to more than 70% take place (Fig. 2). Biosynthesis of starch is chiefly terminated when kernels are yellow. To the end of maturity, starch content decreases sometimes a little on account of a higher synthesis of storage protein. Generally, high contents of sugar correspond with low amounts of starch and vice versa (Table 2).

Fig. 2. *Variation of starch, monosaccharides and total sugars in ripening wheat kernels*

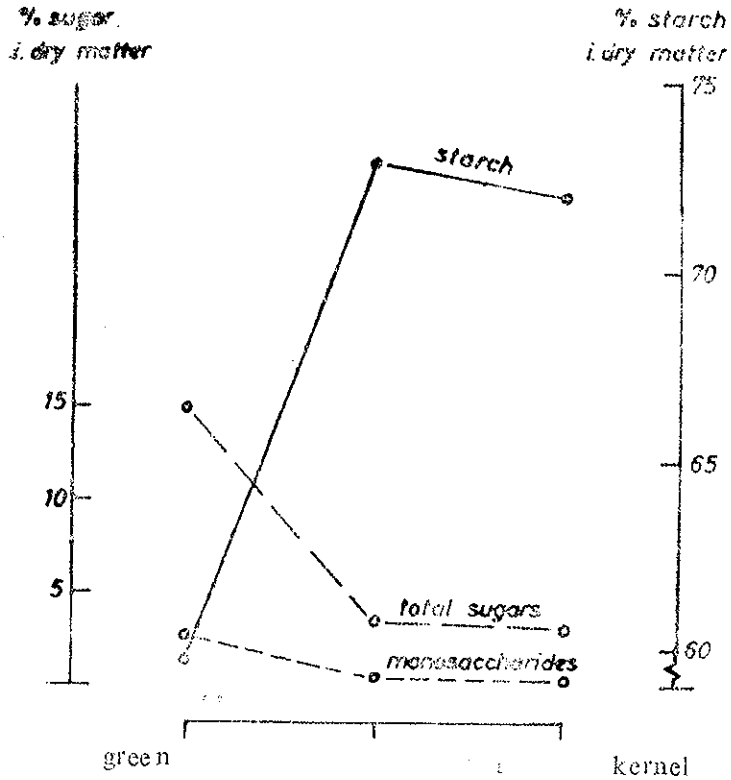


TABLE 2. Total sugars and starch in CCC-treated plants. (Fertilization : 120 kg N/ha).

Criteria % in dry matter	CCC L/ha	Ripening process		
		Green	Yellow	Fully-mature kernels
Total sugars	0	8.1	4.2	3.3
	1.25	9.5	4.4	3.0
	3.75	10.0	4.1	3.1
Starch	0	65.1	72.3	65.8
	1.25	64.0	71.5	65.2
	3.75	63.5	71.2	63.8

Green CCC-treated kernels show distinctly higher contents of total sugars (the same prevails for monosaccharides) : but in yellow and especially in fully-mature kernels there are only slight differences. Starch content in CCC-treated kernels lies in every stage of development by 1-2% lower than in the controls.

In an experiment with rising nitrogen supply and normal (low) CCC application, analysis of mature kernels (Table 3) showed that in fully-mature wheat kernels, the influence of CCC is very small and negligible compared with marked differences caused by high amounts of nitrogen, *i.e.* nitrogen effect predominates.

TABLE 3. **Influence of nitrogen supply and CCCtreatment on sugar and starch content of fully-mature kernels.**

N-supply kg/ha	Without CCC		With CCC	
	Total sugars	Starch	Total sugars	Starch
	% in dry matter		% in dry matter	
0	4.22	71.9	4.18	71.9
60	4.26	72.7	4.27	72.0
120	4.11	71.5	4.16	70.2
160	3.94	69.1	3.97	68.7

b) *Nitrogen metabolism*

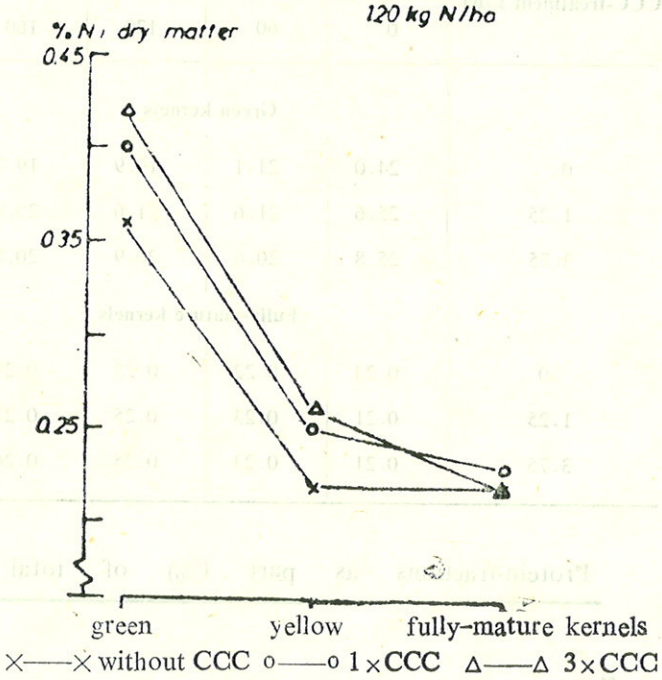
Soluble nitrogen compounds (amino acids and amides) are a measure of maturity stage of kernels and there is an indirect correlation between high conents of soluble N and low baking-quality of flour. Therefore, we tested the influence of CCC on soluble nitrogen and different protein fractions (Fig. 3).

First : During ripening process, soluble-N decreases very much from about 0.45% to 0.15% N in dry matter, the main drop takes place when green kernels become yellow.

Second : CCC-treated kernels show in the early stages a definitely higher content of soluble-N, which means that the ripening process is delayed, the influence of nitrogen is much slighter than that of CCC (Table 4).

A comparison of fully-mature wheat kernels supplied with different amounts of nitrogen and respectively CCC shows clearly that also in this stage the effect of nitrogen is by far more prevalent than of CCC (Table 4). In the early stages of building up kernels (green), there is a definite influence of CCC on higher soluble N-content ; but it nearly disappears later on. The effect of nitrogen is much higher either in early or in mature stages of ripening.

Fig. 3· *Soluble N-compounds in ripening grain of CCC-treated wheat*



Proteins are very important components of wheat grains because of their nutritive value and especially for baking quality purposes. They improve physical and structural properties of dough and hence the quality of the product.

During ripening process there is a marked decrease of albumin, whereas globulin mainly prolamin and glutelin show a substantial increase (Fig. 4).

There is a small visible effect of CCC on protein fraction especially in higher amounts of albumin in green kernels, which can be estimated as a sort of delay in ripening. But in matured kernels no significant change is given. Nitrogen supply predominates in every case and induces the known variations (Table 5).

3. As wheat flour is an important food-stuff, investigations were carried out for determination of CCC residues in kernels by column chromatography method.

TABLE 4. **Soluble nitrogen of CCC-treated wheat kernels (% of total-N)**

CCC-treatment L/ha	Nitrogen supply, kg N/ha			
	0	60	120	160
	Green kernels			
0	24.0	21.1	19.9	19.7
1.25	25.6	21.6	21.6	20.4
3.75	25.8	20.6	20.9	20.1
	Fully-mature kernels			
0	0.24	0.22	0.25	0.29
1.25	0.21	0.23	0.25	0.27
3.75	0.21	0.23	0.25	0.26

Fig. 4. Protein-fractions as part (%) of total N

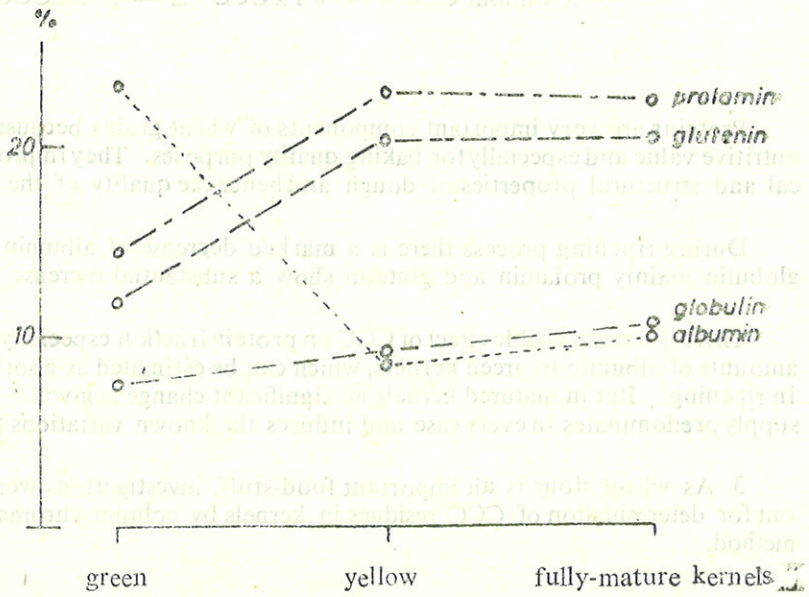


TABLE 5. Protein fractions in ripening kernels (% Protein-N in dry matter).

Protein Fractions	CCC L/ha						N-Supply kg /ha					
	0		1.25		3.75		0		120		160	
	Green	Mature	Green	Mature	Green	Mature	Green	Mature	Green	Mature	Green	Mature
Albumin	0.47	0.15	0.43	0.20	0.49	0.20	0.40	0.20	0.43	0.20	0.47	0.23
Globulin	0.13	0.23	0.14	0.21	0.15	0·22	0.11	0.20	0.14	0.21	0.17	0.24
Prolamin	0.21	0.44	0.27	0.44	0.26	0.45	0.17	0 38	0.27	0.44	0.30	0.56
Glutelin	0.17	0.43	0.22	0.40	0.25	0.49	0.17	0 37	0 22	0.40	0.29	0.54

The results of this investigation on kernel material of different ripening stages, are as follows (Table 6): In the yield of 1968 we found residues between 0.7-1.5 ppm, and of 1969 about the same values. In ripening wheat 1968 residue contents decrease about 1/3 from green to mature grain but not in 1969. The finally-established (values) are nearly the same in both years. The 1967 CCC residues in mature wheat were extremely low. These results point to a decomposition of CCC during ripening process. Jung and El-Fouly have stated, that CCC residues in rainy years decrease more quicly than in dry years. These results also confirm the statements of Jung and El-Fouly, that during storage, probably an enzymatic decomposition of CCC in the wheat kernel took place.

It should be taken into account that the values 0.7 ppm resulted from an analysis immediately carried out after harvest. Furthermore, CCC-treatment of 0.5-1.0 l CCC/ha is recommended nowadays according to the sensibility of wheat species. But these low residues should satisfyeven extremely critical demancs, which are justified, on bread cereals for human consumption.

A negative influence of CCC on the quality of kernels cannot be expected, provided that wheat crop is harvested fully-mature and CCC-application does not exceed the recommendations.

TABLE 6. CCC-residues in ripening wheat kernels (fertilization : 120 kg N/ha).

CCC-treatment L/ha		CCC-residues (ppm in dry matter of kernels)		
		green	yellow	mature
1968	1.25	1.1	0.9	0.7
	3.75	1.5	1.4	1.0
1969	1.25	0.9	0.9	0.7
	3.75	1.3	1.3	1.3
1967	2.0	after 2 years storage		0.04
	1.5	after 2 years storage		0.24

Open Discussion

Q_1 Does CCC have any poisonous effects on human beings ? What about its degradation ?

Dr. A. El-Debaby
Shubra Polytechnic.

Answer

No poisoning effect on human health : Regulations on CCC residues are very severe in our Country. Degradation takes place relatively quickly in soils of high biological activity.

Q_2 Does the treatment of wheat with herbicides of the classes phenoxyaliphatic and substituted benzoic acids change the beneficial effects of CCC?

Dr. W. Furness
Velsicol Chemical Corp., Beirut.

Answer

In my opinion, benificial effects of CCC do not change when combined with herbicides of the classes above, but I have not worked on that myself.

Q_3 What was the stage of growth of wheat at the time of application of CCC and are the CCC dosages expressed in kg active ingredient per hectare?

C.D. Lindley
Cyanamid, Zurich.

Answer

At a stage of about 15-20 cm high. Dosages in kg concentrate/ha.

تأثير السيكوسيل على الأيض الكربوهيدراتى والنيتروجينى فى حبة القمح خلال النضج

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درست احتمالات تأخير نضج الحبوب عند استعمال السيكوسيل بواسطة تقدير النشا وكل من السكريات الأحادية والثنائية والنيتروجين الذائب ومكونات البروتين المختلفة فى الحبة وكذلك كميات السيكوسيل المتبقية فى الحبة خلال مراحل نضجها المختلفة .

أظهرت النباتات المعاملة بالسيكوسيل تحت نفس المستوى الأزوتى محتويات أعلى من النيتروجين فى نهاية فترة النمو الخضرى . وتتميز مراحل النضج المختلفة فى الحبة (النضج الأخضر و النضج الأصفر والنضج الكامل) بنقص واضح فى السكريات الاحادية والسكر الكلى والنيتروجين الذائب . وتحتوى حبوب النباتات المعاملة بالسيكوسيل فى مرحلة النضج الأخضر على كميات من هذه المكونات أكبر مما يوجد فى حبوب النباتات غير المعاملة . وظهرت هذه الاختلافات جزئيا فى مرحلة النضج الأصفر أما فى مرحلة النضج الكامل فلم تظهر أى اختلافات تذكر .

وعادة ينتهى تكوين النشا فى الحبوب فى مرحلة النضج الأصفر . وجدت فى حبوب النباتات المعاملة بالسيكوسيل كميات من النشا أقل من تلك التى وجدت فى حبوب نباتات غير معاملة فى مرحلتى النضج الأخضر والأصفر الا أن هذه الفروق لم تظهر فى مرحلة النضج الكامل . كذلك وجد أن تأثير النيتروجين على خفض نسبة كمية النشا فى الحبوب أكبر من تأثير السيكوسيل .

وبالنسبة الى مكونات البروتين ، لوحظ أنه مع تطور النضج يقل محتوى حبوب النباتات المعاملة وغير المعاملة من الألبومين بدرجة كبيرة فى حين أن الجلوبيولين لا يقل كثيرا أما البرولامين والجلوتين فهى تزداد وبالذات تحت تأثير التسميد الأزوتى العالى المتأخر . لم يظهر أى تأثير يذكر للسيكوسيل على نسب هذه المكونات فى الحبة .

من هذا نرى أن المعاملة بالسيكوسيل تؤدى فى المراحل الأولى لتكوين الحبة الى تأخير واضح فى النضج . باعتبار أن النباتات تحصد بعد تمام نضج الحبوب فانه لا يوجد أى احتمال بأن معاملة القمح بالسيكوسيل تؤدى الى خفض قيمة الحبوب الناتجة .

كما قدرت كميات السيكوسيل المتبقية فى المراحل المختلفة لنضج الحبوب باستخدام طريقة جديدة للفصل الكروماتوجرافى باستخدام الأعمدة . فوجدت بالحبوب كميات تختلف باختلاف كمية السيكوسيل المستخدمة (١ – ٢ لتر / هكتار) . وبتقدم مراحل نضج الحبوب وبتقليل الكميات المستخدمة وصلت الكميات المقدرة فى الحالات العادية لاستخدام السيكوسيل تحت الظروف التطبيقية الى كميات أقل بكثير من المسموح به .

كذلك لوحظ أن كمية السيكوسيل المتبقية فى الحبوب تقل كثيرا فى حالات هطول أمطار كثيرة خلال مرحلة النمو الخضرى .