ORIGINAL ARTICLE

CHANGES OF WEIGHT AND IN-KERNEL CONTENT VALUES OF MAIZE HYBRIDS (OCCITAN, COLOMBA, DK-471) AS A RESULT OF DAMAGING BY EUROPEAN CORN BORER (OSTRINIA NUBILALIS HBN)

KUKORICA HIBRIDEK (OCCITAN, COLOMBA,DK-471) SÚLY- ÉS BELTARTALMI ÉRTÉK VÁLTOZÁSA A KUKORICAMOLY (OSTRINIA NUBILALIS HBN.) KÁROSÍTÁSA KÖVETKEZTÉBEN

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ÖSSZEFOGLALÁS

Vizsgálatunkat 2001-ben két tábla három különbözo hibriddel elvetett állományában vizsgáltuk véletlenszeru mintaterek kijelölésével. Elso felmérésünket egy 120 ha-os COLOMBA és OCCITAN, míg a második vizsgálatunkat egy 50 ha-os DK-471-es hibrid vegetációjában végeztük. Értékelésünk az egészséges és a károsított növények által nevelt csövek közötti súly-, fehérje, zsír és keményíto tartalom különbségeket célozta meg.

A hibridek a kukoricamoly károsítására egyértelmu csosúly-vesztéssel válaszoltak. A COLOMBA zsírtartalmának, míg az OCCITÁN keményítotartalmának csökkenése szignifikánsan összefüggött a kukoricamoly károsításával. Az eredmények azt mutatták, hogy a fehérje, zsír és keményíto anyagcseréje, beépülése is igazolhatóan zavart szenvedett. Megállapítottuk, hogy lárvaszám növekedése és a hibrid szem-csutka aránya között szoros, szignifikáns kapcsolat van. A lárvakárosítás helye illetve a lárvaszám nagymértékben meghatározza a DK-471-es kukorica hibrid csöveinek súlyát és a szemekbe beépülo alapveto tápanyagok (nyersfehérje, nyerszsír, keményíto) mennyiségét.

KULCSSZAVAK: kukorica, hibrid, beltartalmi érték, kukoricamoly, lárva

ABSTRACT

The research was conducted in the year 2001 on two fields sown with three different maize hybrids and was based on randomly chosen sample plots. The first survey was carried out on the field sown with hybrids COLOMBA and OCCITAN (total area 120 ha), the second survey was performed on 50 ha of hybrid DK-471. The assessment was focused primarily on the difference between the cobs developed by healthy and damaged maize plants with regards to their weight and the content of protein, fat and starch in the maize kernel.

The hybrids unambiguously reacted to infestation by the European Corn Borer by cob weight reduction. The decrease of kernel fat content in the case of COLOMBA and that of the starch content in the case of OCCITAN displayed significant dependence on the degree of infestation by the European Corn Borer. The results of the survey verifiably showed that in both cases either metabolism, or incorporation of protein, fat and starch had experienced disorder.

A close link has been ascertained between the growth of larvae population and the kernel-cob rate of the examined hybrids. The distribution and number of larvae significantly affected the weight of maize cobs of hybrid DK-471 and the quantity of the basic nutrient components (raw protein, fat and starch) incorporated in the kernel.

KEY WORDS: maize, hybrid, kernel content, European Corn Borer, larvae

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DETAILED ABSTRACT

The objective of our field survey was to investigate what cob damage and reduction of the in-kernel content values can be caused by the European Corn Borer to the maize grain yield beside the root lodging and tassel breaking. We have tried to find out, to what degree this reduction depends on the individual tolerance of the hybrids towards the European Corn Borer as well as on the varying number and distribution of larvae inside the maize plant.

The research was conducted in the year 2001 on two fields sown with three different maize hybrids and was based on randomly chosen sample plots. The first survey was carried out on the field sown with hybrids COLOMBA and OCCITAN (total area 120 ha), the second survey was performed on 50 ha of hybrid DK-471. The assessment was focused primarily on the difference between the cobs developed by healthy and damaged maize plants concerning their weight and the content of protein, fat and starch in the maize kernel.

The hybrids unambiguously reacted to infestation by the European Corn Borer by cob weight reduction. The decrease of kernel fat content in the case of COLOMBA and that of the starch content in the case of OCCITAN displayed significant dependence on the degree of infestation by the European Corn Borer. Disregarding the genetic distinctions between the two hybrids, the results of the survey verifiably showed that in both cases either metabolism or incorporation of protein, fat and starch had experienced disorder. A close link has been ascertained between the growth of larvae population and the kernel-cob rate of the examined hybrids. The distribution and number of larvae significantly affected the weight of maize cobs of hybrid DK-471 and the quantity of the basic nutrient components (raw protein, fat and starch) incorporated in the kernel.

INTRODUCTION AND BIBLIOGRAPHICAL REVIEW

In Hungary, maize is cultivated on the total area of more than 1 million ha, which is why great attention should be paid to the careful investigation of the yield-decreasing factors, as well as to the examination and accurate assessment of the related biological and economic damage. Up to nowadays, the most important maize pest in this country has been the European Corn Borer. Although damage caused by this pest varies year to year, it remains a factor that should be always taken into account. The source of the damage is the worm which destroys the inside of the maize stalk and in this way prevents the normal traffic of nutrients within the plant, thus slowing down its development. A number of authors [12, 14] consider this form of damage primary damage, as opposed to the losses that originate from root lodging and are referred to in the special literature as signs of secondary damage. In the past, a perfect source of infestation on small peasant farms used to be piles of maize stalks which served a safe winter home for the pest [10]. With the implementation of advanced industrial-like crop production, the scale of damage by the European Corn Borer showed permanent growth [6]. As numerous surveys display, the increasing intensity of maize cultivation, the raising average yields [2] and the spread of monoculture maize production were accompanied by the rise of the damaging effects of the European Corn Borer [5]. Presently, the population of *Ostrinia nubilalis* [13] and the scale of damage inflicted by it are both fairly high [8].

The damage caused by the European Corn Borer has been the subject matter of quite a few publications, equally by home and foreign authors. Percentage of infestation and damage estimates vary widely. In surveys by Hertelendy and Szabó [7], the loss rate at 69% stalk infestation amounts to 11% of the potential yield, that is 740 kg per hectare. Of this, the damage resulting from the cob weight reduction makes 512 kg, whereas the root lodging accounts for the loss of 228 kg. Yield reduction grew proportionally to the number of larvae discovered inside the stalk. The study of the problems related to the vertical distribution of larvae inside the stalk and modelling of the process were done with greater detail by Labatte [9]. Manninger's [11] estimate of the yield loss was 20% at 68% infestation. According to Anglade [1], the loss per hectare can even reach 2000 kg. Upon 10 years of research, Chiang [3] arrived to the conclusion that one larva of the first generation decreases the yield obtained from one plant by 3%. Dolinka [4] reported 3.5-5.9% yield loss by early-maturing hybrids, 2.6-2.9% by medium-early and 7.7% by medium-late hybrids. The scale of the inflicted damage is determined, among other factors, by the time of symptoms' appearance, which can be partly explained, along with abiotical reasons, by the individual properties of the given hybrid. The impact of the photoperiod and temperature factors on the diapause of the European Corn Borer was thoroughly explored by Sáringer [15].

Thus, it is evident that the scale of damage is defined by the percentage of infestation, the time of its onset and the prevailing weather conditions. Along with abiotical (temperature, moisture content, precipitation) and biotical (connexion with the host plant, natural enemies) reasons, the individual features of maize hybrids, the time of the infestation onset, the number and distribution of larvae are of crucial importance. Obviously, a decisive role belongs to the varying tolerance of maize hybrids towards *Ostrinia nubilalis*, as well as to the larvae population and its distribution inside the maize plant; this finds its reflection in the reduced weight of the damaged cobs and varying incorporation values of in-kernel components.

MATERIAL AND METHOD

The survey was staged in 2001, on two different fields on the border of Somogyszil, at varying time. The sensitivity and variance studies of the hybrids were done during the first weeks of October on a single plot of 120 ha where maize had been cultivated in monoculture. Half of the plot (60 ha) was sown with maize hybrid COLOMBA, while the other half (60 ha) – with hybrid OCCITAN. The larvae population and its localisation inside the plants were studied in the end of October on a 50 ha field. The preceding crop on this field had been wheat; after harvesting, upon basic fertilizing and timely soil preparation, the field was sown with maize hybrid DK-471. The agrotechnical operations and crop protection were carried out in accordance with the plants' requirements and appropriately to their phenological stage of development. Not on a single plot was protection against European Corn Borer applied. The main condition for the choice of the survey time was that maize should have already completed its vegetation, so that the signs of damage inflicted by the European Corn Borer should be clearly visible and assessable.

The survey was carried out on randomly picked sample plots, in series of four replications on the 120 ha field and three replications on the 50 ha field, in such a way that within each replication 20 plants were picked for examination from 20 rows situated immediately beside one another. Apart from registration of the pest's presence on the sample plot, percentage of the infestation was also determined.

In the course of the hybrids' sensitivity study and variance test, for the calculation of the yield loss, we broke cobs from 10 infested and 10 intact maize plants. While studying the association between the pest population and the distribution of the larvae inside the stalk, apart from the signs of the so-called secondary damage, all plants of the inspected plot were searched for penetration holes, as well as remnants of chewed matter and traces of faeces.

During the second survey, the cobs of 10 intact plants from every sample plot, as well as all plants (with cobs) showing signs of infestation by *Ostrinia nubilalis* were taken to the laboratory, where upon cutting up the stalks the number and distribution of larvae was established. After that, the experimental material was re-organised into five sample groups, each containing the cobs developed by 10 maize plants. The following cases were thus represented: a healthy plant; a plant with one larva discovered beneath the cob; a plant with one larva above the cob; a plant with two larvae; a plant with three larvae. Because plants with three larvae were scarce, this experimental group was formed of the cobs that had been gathered from three sample plots.

The cobs obtained from hybrids COLOMBA and OCCITAN were weighed; based on the weight variance, the specific weight loss per area unit was calculated. The samples of hybrid DK-471 were measured once for the whole cob weight and then separately for shelled kernels' and empty cob weight. Based on these data, the weight loss, the change of kernel-cob rate and the difference of the kernel-cob rate were determined. Further, the effective yield reduction was calculated using the following function: $ETCS = F*f/100$, where F = percentage of infestation; f = yield difference between the damaged and the intact plants in percent [4].

For each sample group of both surveys, the content (in percent) of the following components of the shelled kernels was determined: dry matter content (air-dried); moisture content; the rates of raw protein, raw fat and starch. The kernel raw protein content was established by means of the macro-Kjeldahl-Winkler (bor acid-using) method, the raw fat content – according to Soxhlet, the starch content – according to Ewers in the laboratory of theDepartment of Animal Physiology and Nutrition at the Georgikon Faculty of the University of Veszprém. The weight data and the in-kernel content values obtained from the analysis of the samples and sample groups were statistically processed using „Statistics for Windows 2.0".

RESULTS

The established percentage of infestation appeared to be nearly equal for both examined hybrids. By both COLOMBA and OCCITAN the infestation was registered unanimously at 23%. The data of Table 1 clearly indicates that the damage caused by the European Corn Borer has brought forth substantial weight reduction which in the case of both hybrids induced approximately 20-25% loss. The table also shows that weight reduction was less in the case of OCCITAN, which in this instance made 3.18% difference in the yield loss. The content of dry matter as well as the related water, raw fat (%), raw protein (%) and starch (%) rates in the samples dried at 60^{o} C are summarized in the first six lines of Table 2. The table only contains the average values of the examined samples. In the damaged lots, the kernel content values also show unambiguous decrease, unlike the dry matter content (air-dried) values that appeared higher.

Table 1: Weight of the maize cob samples

	COLOMBA								OCCITÁN							
	Healthy cobs				Damaged cobs				Healthy cobs				Damaged cobs			
Sample No.	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total weight of 10 cobs (kg)	2.40	2.30	2.56	2.62	1.80	1.96	2.02	1.72	2.10	2.08	1.60	2.08	1.90	1.86	1.25	1.16
Total weight of the sample (kg)	9.90				7.50				7.86				6.16			
Weight loss (%)	24.25								21.63							
Average sample weight (kg)	0.247				0.187				0.196				0.155			
Weight loss (%)	24.30								21.12							

Table 2: In-kernel air-dry (60°C) content values of the maize cob samples

		Dry matter at 60°C (%)	Moisture at 60°C (%)	Raw protein (% of dry matter)	Raw fat (% of dry matter)	Starch (% of dry matter)
COLOMBA	Intact cobs	74,30	25,70	8,42	3,52	64,43
	Damaged cobs	77,42	22,57	7,94	3,17	63,89
	Difference	+3,12	-3,13	-0,48	-0,35	-0,54
OCCITÁN	Intact cobs	80,05	19,95	8,60	3,37	63.35
	Damaged cobs	84,27	15,73	8,46	3,30	60,10
	Difference	+4,22	-4,23	-0,14	-0,07	-3,24
DK-2471	Intact cobs	84,61	15,38	8,97	3,95	64,13
	One larva under the cob	84,91	15,08	8,66	3,86	63,92
	Difference	+0,3 ▲	-0,3 ▼	-0,31 ▼	-0,08 ▼	-0,21 ▼
	One larva above the cob	86,9	13,1	8,71	3,86	63,89
	Difference	+2,29 ▲	-2,29 ▼	-0,26 ▲	-0,08 ▼	-0,24 ▼
	Two larvae	87,34	12,66	8,59	3,78	62,95
	Difference	+2,73 ▲	-2,72 ▼	-0,38 ▼	-0,17 ▼	-1,18 ▼
	Three larvae	87,36	12,64	8,46	3,81	62,57
	Difference	+2,75 ▲	-2,74 ▼	-0,51 ▼	-0,14 ▲	-1,56 ▼

The larvae of the European Corn Borer infested 15% of the maize stalks on the 50 ha field. Laboratory analysis of the infestation rate according to the number of larvae and their distribution inside the plant can be summarized as follows: one larva underneath the cob: 30%; one larva above the cob: 44.5%; two larvae per plant: 24%; three larvae per plant: 1.5%. Table 2 displays the values and difference in the values of the dry matter content, moisture, raw protein, raw fat and starch content of the samples (category by category) dried at 60° C. As a result of growth of the larvae population, an increase in the dry matter content and a reduction of the in-kernel values can be observed. Regarding the effect of larvae distribution, the plants with one larva above the cob show decreased values for all of these parameters, except for the raw protein content.

Table 3 shows the distribution of weight values in each of the above groups, including weight of the whole cob, weight of the shelled kernels, the empty cobs, and the grain yield loss. Obviously, the correlation between the increasing larvae population and weight loss is logarithmic. The plant proved to be more sensitive to the joint damage caused by two larvae, whereas in the case of the third larva the rapid weight loss was reduced. In the case of one larva per plant, the position of the larva also affected the cob weight. The plant appeared to be more vulnerable to the damage caused by a larva situated above the cob.

Table 3: The samples' average kernel and cob weight / weight loss

		Intact cobs	One larva under the cob	One larva above the cob	Two larvae	Three larvae
Sample average weight (kg)		0,216	1,195	0,189	0,128	1,105
Weight loss	g	-	20,75	27,16	88	111,16
	%	-	9,57	12,53	40,61	51,3
Sample average kernel weight		0,184	0,167	0,163	0,111	0,091
Weight loss	g	-	16,66	21	72,66	92,53
	%	-	9,04	11,4	39,45	50,24
Sample average cob weight		0,0325	0,0284	0,0263	0,0173	0,0138
Weight loss	g	-	4,08	6,2	15,17	18,63
	%	-	12,56	19,07	46,67	57,32

We carefully studied the data reflecting the cob-kernel weight rate. As a reaction to a larger damage, the proportion of cob-kernel components shifts towards prevailing kernel weight. The difference in the cob-kernel rate shows a slightly linear growth from „one larva beneath the cob"-related damage through to „three larvae"-damage. The difference in the cob-kernel rate varies within a similar trend as the change of the weight loss values. During the analysis of the cob components rate, it was discovered that by each of the sample groups, the growth of kernel weight was followed by a roughly six-sevenfold decrease of the cob weight.

We calculated the effective yield decrease, weight loss and reduction of raw protein, raw fat and starch content on the 50 ha field, both for their specific and percentage values. The percentage rates of losses caused by different damage types were also calculated. Data reflecting the above specific damage calculated for one hectare and one plant are displayed in Table 4. The losses calculated both per hectare and per plant appeared to be of the same scale in the case of all the three parameters. The per-hectare loss of raw protein, raw fat and starch content reached about 3%, whereas the per-plant decrease of the above quality parameters showed a unanimous 20% loss. By assessing the per-field distribution of the damage types, the damage caused by two larvae proved to be the most significant of all, whereas the damage inflicted by three larvae turned to be the least important type, apparently due to its low occurrence.

During statistical processing of the obtained data the following relationships were discovered:

By hybrid COLOMBA positive correlation (P=99.8%) has been determined between the infestation-related damage and the reduction of the raw fat content. It can be stated that this hybrid reacts to stronger infestation by drastic fat loss (r=0.9037). A close link has been found between the infestation rate and its impact on the average kernel weight (P=99.3%, r=0.6407). This can be explained by a substantial drop in the raw fat content due to the chewing of the stalk by larvae of the European Corn Borer. In the case of this hybrid a strong correlation has been revealed between the raw fat content and the average kernel weight (P=99.7%, r=0.8862). Some loss in raw protein has also been experienced, although not so much depending on the effects of infestation as in the case of the raw fat loss mentioned above. By COLOMBA no connection has been registered between infestation and starch content (P=39.6%, r=0.2177).

By hybrid OCCITAN the change of in-kernel values showed a different trend. A positive correlation has been revealed between the infestation rate and the kernel starch content (P=96.8%). The increasing infestation of this hybrid brings forth substantial decrease of the starch content.

Table 4: Summary of actual per hectare losses

			One larva under the cob	One larva above the cob	Two larvae	Three larvae
Distribution of damage types		%	30	44,5	24	1,5
		db	3060	4539	2448	153
Total raw protein per hectare	Loss due to infestation (kg)		4,9			
	Loss due to weight reduction (kg)		25,63			
	Overall loss (kg)		30,53			
	Loss (%)	per hectare	3,21			
		per plant	21,42			
Proportion of various damage types in the overall raw protein loss (%)			17,52	29,7	48,9	3,89
Total raw fat per hectare	Loss due to infestation (kg)		1,67			
	Loss due to weight reduction (kg)		11,27			
	Overall loss (kg)		12,94			
	Loss (%)	per hectare	3,09			
		per plant	20,63			
Proportion of various damage types in the overall raw fat loss (%)			16,22	29,9	50,77	3,88
Total starch per hectare	Loss due to infestation (kg)		7,63			
	Loss due to weight reduction (kg)		183,3			
	Overall loss (kg)		190,93			
	Loss (%)	per hectare	2,81			
		per plant	18,74			
Proportion of various damage types in the overall starch loss (%)			14,99	27,95	52,83	4,21
Total maize cobs weight per hectare	Loss due to infestation (kg)		341,9			
	Loss (%)	per hectare	2,73			
		per plant	18,21			
Proportion of various damage types in the overall loss (%)			15,29	28,6	51,97	4,13
Effective yield reduction (E.T.CS)			4,08			

Note: The 'per-hectare' weight loss which served as a basis for the calculation of the total weight loss was viewed as full value, healthy forage crop (corrected for dry (air-dried) matter), since we had no knowledge of the changing of individual nutrient components during weight reduction.

Regarding the other two content parameters no relevance to the damage caused by the European Corn Borer was registered. Nevertheless, the relation between the starch content and the average weight has proved quite significant (P=94.5%; r=0.6971), although not as closely linked as the kernel weight and fat content change in case of hybrid COLOMBA.

The (air-dried) dry matter content and, subsequently, the kernel moisture content by both hybrids can be brought into relation with the infestation rate. The correlation analysis shows 99.5% significance by OCCITAN and 90.1% significance by COLOMBA.

Based on the assessment of the data obtained from the analysis of combined samples, a comparative study of the target hybrids was carried out with the focus on the variance of their kernel content values. It has been discovered that change of the starch content resulting from the infestation by the European Corn Borer depends to a large extent on the individual properties of the given hybrid (P=97.9%; r=0.5698). The raw fat content change resulting from the infestation damage, however, cannot be explained by varying features of individual hybrids (P=11.9%); it should be rather interpreted upon consideration of the impacts produced by other factors (e.g. moisture content).

Hybrid DK-471 reacted to the increase of larvae population by a significant growth of the dry matter content (P=99.7%; r=0.755) accompanied by a substantial and closely linked cob (P=100%; r= - 0.887) and kernel (P=100%; r= - 0.896) weight reduction. The increase of cob-kernel rate showed 99.6% significance as a result of the increased larvae population. Positive correlation has been registered between the number of larvae and the variance of raw fat and starch values, of which the raw fat appeared to be more sensitive to the larvae damage (P=99.9%; r= - 0.802). The impact of the pest population on the change in the starch content also appeared to be negative, showing only minor correlation (P=90.2%) with a looser link (r= -0.479). Thus, the plants react to the growing larvae population by drastic reduction of the raw fat content and a less pronounced decrease in the starch content. No statistically proof relationship could be found between the changing kernel protein content and the growth of larvae population (P=83.4%; r=0.391). Effects of the larvae distribution on any of the measurable quality parameters could only be statistically confirmed in case of the dry matter content (P=98.7%). It could be likely, however, that lack of significance in more that one instance is the consequence of an insufficient sample number and the low weight of the measured values resulting from it.

While the change of the cob (P=97.5%; r=0.617) and kernel (P=98.2%; r=0.691) weight affected the incorporation of raw fat into the kernel, these factors, however, produced no impact on the incorporation of protein and starch.

The reduced moisture content resulting from the growth of larvae population and the varying distribution of larvae inside the plant also had significant consequences for the incorporation of raw fat content into the kernel, although with a looser correlation (P=97,5%; r=0,481).

We attempted to research the mutual influence of changes in the kernel content values induced by various types of damage, but failed to find statistical proof of any such relationship.

CONCLUSIONS

A 23% infestation by the European Corn Borer of maize fields where maize is cultivated in monoculture can be assessed as average. The degree of stalk infestation registered at the second survey appeared to be lower (15%) than the results of the first survey, apparently due to the fact that the preceding crop (wheat) had not left behind an imago population of the previous generation. In the case of maize cultivated under crop rotation, the stalk infestation was still fairly high, which can be explained by the individual properties of the field location (warm, wet environment).

The weight reduction by the examined hybrids appeared to be closely related to the infestation by European Corn Borer. The difference in the hybrids' yield loss can be explained by the drastic decrease of raw fat content in the case of hybrid COLOMBA, because it significantly affects the average weight values. By hybrid OCCITAN, not a single in-kernel parameter could be brought into so close a relationship with the average weight.

As a result of infestation, all the three hybrids displayed reduction of their kernel moisture content due to the physiological processes that get started as the plants' reaction to stress. In the course of the survey it was established that maize reacts to chewing by the Corn Borer larvae by pre-mature ripening.

It can be claimed that a relationship – no matter how varying – has been discovered between the decrease of the three in-kernel content parameters and the damage caused by infestation. The link between the in-kernel raw fat and starch content levels and the damage inflicted by the Corn Borer is close, significant, whereas changes in the raw protein content can only to a minor degree be explained by the pest's activity.

Along with the effects of infestation, the varying changes of the hybrids' in-kernel starch content can be also explained by the individual features of the examined hybrids. On the opposite, the variance of the raw fat content changing does not depend on the hybrid's specific properties and is a quality influenced by other factors.

The harmful effect of the larva situated underneath the cob is less important in terms of either percentage of its occurrence or the damage scale, as compared to the damage caused by one larva chewing the maize stalk above the corn-cob. The reason for this can be that in terms of the leaf surface and assimilation activity the leaves situated in the six-seven internodes under the cob fall behind those situated in the internodes above the cob. However, we have not succeeded in finding statistical confirmation of such difference.

The weight loss by the examined hybrids is closely connected with the number and distribution of larvae inside the stalk. It has been determined that the plant reacts to a larger damage of the transport vascular bundle by a changing cob-kernel rate. As a reaction to stress, the plant does not only intensify the development of its generative parts, but also during cob formation the "full value" kernels enjoy priority as opposed to the corn cob.

It can be claimed that a relationship – no matter how varying – has been discovered between the decrease of the three in-kernel content parameters and the number and distribution of larvae inside the stalk. The impact of the larvae population and distribution on the in-kernel dry matter content is fairly significant, whereas the raw fat and the starch content values have appeared sensitive only to the number of larvae, while the raw protein content has displayed no dependence at all on either of the two circumstances.

Disclosure of the factors which influence the quantity changes in the raw fat and starch content of hybrids COLOMBA and OCCITAN as well as the distinctions displayed by the examined hybrids in this respect; further, research of the starch and, still more importantly, the reduction of raw protein values as a result of growing damage (which, of course, are phenomena influenced by other factors as well) raises more questions and requires further exploration.

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