

EFFECT OF NUTRIENT SUPPLY ON FRUIT QUALITY OF APPLE (*Malus domestica* BORKH.)

A TÁPANYAGELLÁTÁS HATÁSA AZ ALMA (*Malus domestica* BORKH.) GYÜMÖLCSMINŐSÉGÉRE

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ABSTRACT

Observations were carried out in the eastern part of Hungary. In this experiment we studied the nutrient supply-reaction of four apple cultivars (Golden Delicious, Granny Smith, Idared and Jonathan Csány) under different N- and NPK-doses. The following fruit quality parameters were detected: fruit diameter, fruit height, fruit weight, flesh firmness, colour-cover and we studied the thicket of foliage of trees.

The research results showed, that N-fertilization has a great effect on fruit quality. This appears in the cases of increase of fruit largeness. The increase is proportional to N-levels. Moderate N-doses plus PK-addition had also positive effects. The nutrient supply increased vegetative area in addition to the generative parts, in particular pure N fertilizer. But the thicked foliage hindered the growth of fruit weight and colour-cover, also decreased the fruit quality. And decreased the flesh firmness of cultivars, that has a negative effect on storageability.

KEY WORDS: apple, fruit quality, nitrogen, nutrient supply

ÖSSZEFOGLALÁS

Kísérleteinket Kelet-Magyarországon végeztük, ahol négy almafajta (Golden Delicious, Granny Smith, Idared és Jonathan Csány) tápanyagellátási reakcióját vizsgáltuk különböző N- és NPK-adagok mellett. A felvételezett gyümölcsminőségi mutatók a következők voltak: gyümölcsmagasság, gyümölcsmagasság, gyümölcstömeg, húskeménység, fedőszín-borítottság, továbbá vizsgáltuk még a lombkorona-sűrűséget.

Az eredmények azt mutatták, hogy a N-trágyázás jelentős hatást gyakorol az almafajták gyümölcsminőségére. Ez megmutatkozik a gyümölcsmagasság növekedésében. A növekedés többnyire arányos a kijuttatott N-dóziséval. Megfigyeltük továbbá, hogy a közepes N-adag és a mellette kijuttatott PK hatóanyag is igen pozitív hatású volt. A generatív részek mellett a vegetatív felületet is megnövelte a tápanyagellátás, elsősorban a N hatóanyag. Azonban az ilyen módon besűrűsödött lombkorona gátolta a gyümölcstömeg és a fedőszín-borítottság növekedését, ezzel csökkentette a gyümölcs minőségét. De csökkentette a fajták húskeménységét is, ami negatívan hat a tárolhatóságra.

KULCSSZAVAK: alma, gyümölcsminőség, nitrogén, tápanyagellátás

DETAILED ABSTRACT IN HUNGARIAN

Jelen tanulmány célja a tápanyagellátás almafajták gyümölcsminőségére gyakorolt hatásának tanulmányozása, továbbá az egyes gyümölcsminőségi paraméterek közötti kapcsolatok feltárása.

Megfigyeléseinket Kálmánházán, Kelet-Magyarországon egy magántermelői ültetvényben végeztük. A kísérletben négy almafajta (Golden Delicious, Granny Smith, Idared és Jonathan Csány) tápanyagellátási reakcióját vizsgáltuk különböző N- és NPK-adagok mellett. A felvételezett gyümölcsminőségi mutatók a következők voltak: gyümölcsátmérő, gyümölcsmagasság, gyümölcstömeg, húskeménység, fedőszin-borítottság, továbbá vizsgáltuk még a lombkorona-sűrűséget, mint jelentős minőség-befolyásoló tényezőt.

Az eredmények azt mutatták, hogy a N-trágyázás jelentős hatást gyakorol az almafajták gyümölcsminőségére. Ez megmutatkozik, pl. a gyümölcsnagyág (gyümölcsátmérő, gyümölcsmagasság, gyümölcstömeg) növekedésében. A növekedés többnyire arányos a kijuttatott N-dóziséval, ennek megfelelően legnagyobb pozitív különbséget 100 kg×ha⁻¹ N-adag alkalmazása esetén tapasztaltunk. Megfigyeltük továbbá, hogy a közepes N-adag (75 kg×ha⁻¹) és a mellette kijuttatott P és K hatóanyag is igen pozitív hatású volt. Általában megközelítette a 100 kg N alkalmazásának hatását, sőt a Golden Reinders fajta esetében meg is haladta annak értékét. A megnövekedett N-adagok növelték az egyes fajták gyümölcstömegének szórását, míg a kiegyensúlyozott P és K kiegészítések mellett alacsony volt a mutató értéke. A generatív részek mellett a vegetatív felületet (lombkorona-sűrűség) is megnövelte a tápanyagellátás, elsősorban a N hatóanyag. Azonban az ilyen módon besűrűsödött lombkorona gátolta a gyümölcstömeg és a fedőszin-borítottság növekedését, ezzel csökkentette a gyümölcs minőségét. Sőt csökkentette a fajták húskeménységét is, ami negatívan hat a tárolhatóságra.

Lineáris kapcsolatot sikerült kimutatni a gyümölcstömeg és a fedőszin-borítottság, valamint a gyümölcstömeg és a húskeménység között. A kapcsolatok jellege hasonló volt, azonban az iránya ellentétes: a nagy gyümölcstömeg magas fedőszinnel járt, de alacsony húskeménységgel.

INTRODUCTION

In the case of deciduous fruit trees, the factors influencing on fruit quality parameters are so much [8]. Nutrient-supply has direct and indirect significant effects, in particular N-supply [6, 7]. The effect is differ on different plants. At the case of apple the quality of the winter apple was studied in details. (In Hungary especially the Jonathan cultivar). The reason of the researches was that

increase of fertilization resulted such a disharmony, which negatively effected the fruit quality and storageability [3, 9].

The nitrogen uptake in apple trees is rather low in comparison to other crops, most being taken up in the fruits at a quantity of 30-40 kg×ha⁻¹ nitrogen per year under European conditions [12].

Generally it is said that in apple cultivars the pure nitrogen supply can cause firmness, cover-colour, vitamin-C, taste, aroma and even soluble solids content reduce. [4, 9]. The high quantity of nitrogen in soil can cause fruit size-increase in many times, which lead to increase peel- and flesh browning and core rotten [15]. On the other hand there are not only a few studies, in which researchers found different effects or they could not find any [5]. In other experiments pure nitrogen supply can reduce the size of the apple, the average weight, cover-colour, the average of the crop and the total loss [11]. Only the very high levels of nitrogen (1,600 and 3,200 kg×ha⁻¹) caused spot, rotting, and flesh browning, but only in very low degree.

Researchers established that the nitrogen-overdose can cause damage only if we compare the quantity of the calcium to the too high potassium [14]. The nitrogen fertilization damages the storageability and it is appear in indirect way and not in direct [13]. First of all the foliage becomes stronger, the effect of the shading will be stronger, which cause less fruit colouring. The badly cover coloured fruit is susceptible to the illness on the skin - and because of the late harvest - we will have problem with storage as well. Applying nitrogen fertilization the number of the fruit cells are reduce, but the size is increase [2]. The largeness of the cell is in close relation with storageability (with inverse sign).

In a ten-year-research ones compared the pure nitrogen, potassium, phosphorus, calcium and magnesium occur in apple leaf, fruit, bark, root, in ligneous and in sprout [1]. It was established, that there was no important different between the two kinds of nutrition. In practice it was a reduction of fertilization costs in that time. American authors cited to their findings [16]. They found close relationship between the the nitrogen content of leaves and yield, largeness of the fruit and colouring. In that case, if the Golden Delicious nitrogen content in leaves (relating to dry matter) was over 2.2%, fruits become larger and greener. The fruit with high quality was found between 1.9-2.0% nitrogen content.

MATERIALS AND METHODS

Assessments were made in a commercial apple orchard at Kálmánháza, in the eastern part of Hungary, in 2003-2004.

The characteristics of experimental orchard and studied cultivars can be seen in Table 1. Trees were planted in North-South row-direction, and pruned to a spindle shape and grass alleyways were used in the rows.

To study the effect of fertilization we used artificial fertilizer in two parts. We applied it as a base fertilization in solid and granular formulation (100% P, K and 50 kg×ha⁻¹ N) in January, then as a head fertilization in liquid foliar formulation (in the „C” treatment 50, in the „D” treatment 25 kg×ha⁻¹ nitrogen doses) weekly in May. Table 2. demonstrates the conditions of fertilization.

The observation and measurement were carried out on twenty trees per treatment. Figures contain the average of these data. Trees were assigned at the beginning of reasearch. Each cultivar was represented by four blocks and each block by five trees. Five apple fruits were randomly sampled from each tree for this evaluation, so that the total number was 100 per cultivar.

In our investigations, we determined the following properties of apple:

- (1) Fruit diameter: This was measured in 0.1 millimeters with slide-gauge along the greatest transversal outline of fruit.
- (2) Fruit height: This was measured in 0.1 millimeters with slide-gauge along the greatest longitudinal outline of fruit.
- (3) Fruit weight: The weight of fruit was estimated in 0.1 grams with the help of digital analitic scales. Values mean the pure weight without pedicel.
- (4) Flesh firmness: This was measured with Bishop handheld penetrometer (Italy) twice per fruit: on the sunny side and the shaded side along the greatest transversal diameter.
- (5) Colour-cover: This was determined visually in a linear scale (1-100). 1 means the fruit without colour-cover.
- (6) Thicket of foliage: This was determined visually in a linear scale (1-10). In the course of establishing the values of this parameter we took the largeness of leaves, numbers of leaves, thicket of branches into consideration. Low values show thin foliage proportional.

RESULTS AND DISCUSSION

Effects of nutrient supply on fruit quality and other morphological parameter of foliage of tree can be seen in Figures 1-9. Figures 1-3 show the changes of fruit largeness in the cases of studied four apple cultivars, under different nutrient levels.

Research results attest to enlarge the fruit diameter under increasing N-doses (Figure 1). The increase of diameter is

proportional to applied N-doses mostly. In accordance the highest positive difference observed by using 100 kg×ha⁻¹ N-doses. Only the case of cultivar Joanthan Csány was detected similar effect of treatments „A” (0 kg×ha⁻¹ N) and „B” (50 kg×ha⁻¹ N). This shows not the little account of N, but the similarity was caused by winter apply and the agent was rinsed out of the root-zone by rainfall. It is important to note, that moderate N-doses (75 kg×ha⁻¹) plus P-and K-addition had also positive effects. This approached the values of 100 kg×ha⁻¹ N, even exceeded its values by cultivar Golden Reinders.

The nutrient supply had a very similar influence on fruit height too (Figure 2). The increase of fruit height is not so express and values of standard deviation are not high in this case. The most effect was observed by Granny Smith. Values of treatment „D” were all cases higher than „B” and lower than „C” (except Golden Reiners). Values approached „C” treatment’s. As a result of this, phosphorus and potassium agents together bettered the effect of pure nitrogen.

Figure 3 show the changes of fruit weight. The tendency is similar to the previous two parameters, since all of three parameters describe the characteristic of fruit largeness, but in other approach. The highest fruit weight was measured by cultivar Idared, and the lowest by Jonathan Csány. We experienced that increased N-doses enlarged the standard deviation, in the oder hand this parameter was low in the cases of balanced NPK fertilization.

As well known, the nutrient supply increased vegetative area in addition to the generative pieces, in particular only nitrogen fertilizer. Increasing N-doses enlarged the thicket of foliage (Figure 4). The increase of this is proportional to applied N-doses mostly. But we observed that density of foliage increased to a lesser degree under additional PK than only N fertilizer using. In this case the effect of PK kept back N agent’s a certain extent. This appeared that values of „D” treatment in the cases of Jonathan Csány, Idared and Granny Smith were very near to values of control. Tendency of standard deviations was opposite to previous parameters’. Increasing N-doses decreased the standard deviation of foliage thicket and the crown was balanced and compacter.

In the course of this investigation we searched for relationship between fruit weight and thicket of foliage. Results can be seen on Figure 5. The relation was described quadratic polinomial function. This means the biggest fruit weight did not pertain to the highest vegetative area (highest foliage thicket), but values of 7.5-8.0. The apparent contradiction issued from the thicked foliage has a significant shading effect on fruits, and this put a stop to growth of fruits. Under the experiments, we did not observed decrease of fruit weight by increasing

Table 1: Characteristics of experimental orchard and studied cultivars

1. táblázat: A vizsgált ültetvény és fajták jellemzői

Cultivar	Rootstock	Date of planting (year)	Area of block (ha)	Size of parcel (m ²)	In row spacing (m×m)
Fajta	Alany	Telepítés ideje (év)	Terület nagysága (ha)	Parcella nagysága (m ²)	Térállás (m×m)
Golden Delicious	MM106	1998	1.8	700	4.0×1.5
Granny Smith	MM106	1999	0.8	700	3.5×1.5
Idared	M4	1995	4.0	400	3.5×2.0
Jonathan Csány	M4	1993	2.5	400	4.0×2.0

Table 2: Circumstances of fertilization (2003-2004)

2. táblázat: A műtrágyázás körülményei (2003-2004)

Treatment Kezelés	Nutrient agent (kg×ha ⁻¹) Hatóanyag (kg×ha ⁻¹)			Date of getting out Kijuttatási ideje			
	N	P ₂ O ₅	K ₂ O	2003	2003	2004	2004
				Base fertilization Alaptrágya	Head fertilization Fejtrágya	Base fertilization Alaptrágya	Head fertilization Fejtrágya
A	0	0	0	-	-	-	-
B	50	0	0	22 Jan	-	20 Jan	-
C	100	0	0	22 Jan	from 13 May	20 Jan	from 16 May
D	75	50	68	27 Jan	from 15 May	19 Jan	from 18 May

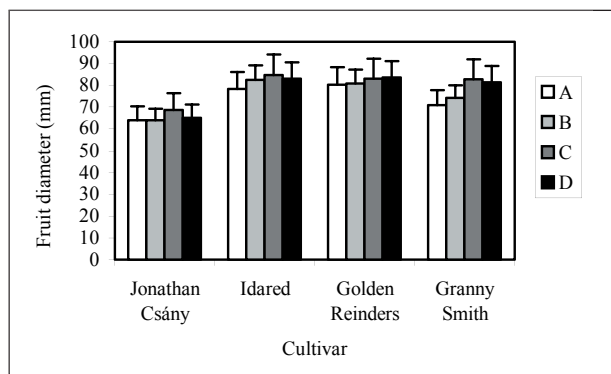


Figure 1: Effect of nutrient supply treatments on diameter of apple fruits

1. ábra: A tápanyagellátás kezelése az almafajták gyümölcsátmérőjére

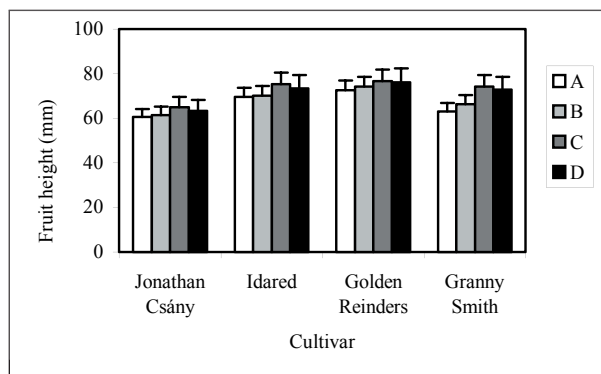


Figure 2: Effect of nutrient supply treatments on height of apple fruits

2. ábra: A tápanyagellátás kezelése az almafajták gyümölcsmagasságára

EFFECT OF NUTRIENT SUPPLY ON FRUIT QUALITY OF APPLE (MALUS DOMESTICA BORKH.)

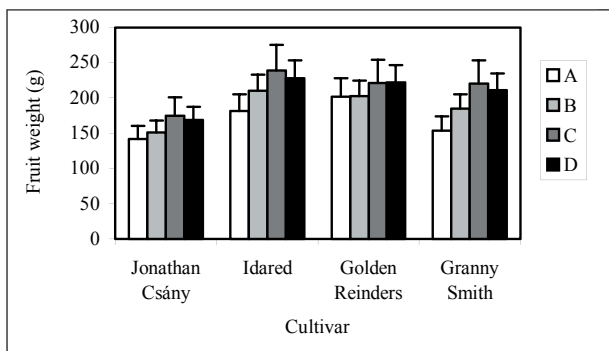


Figure 3: Effect of nutrient supply treatments on weight of apple fruits

3. ábra: A tápanyagellátás kezelések hatása az almafajták gyümölcstömegére

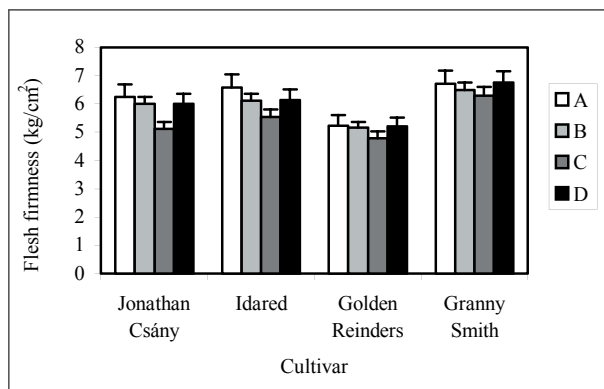


Figure 6: Effect of nutrient supply treatments on flesh firmness of apple fruits

6. ábra: A tápanyagellátás kezelések hatása az almafajták húskeménységére

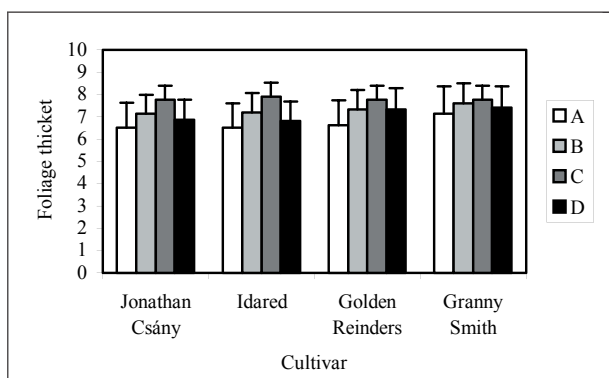


Figure 4: Effect of nutrient supply treatments on foliage thicket of apple cultivars

4. ábra: A tápanyagellátás kezelések hatása az almafajták lombkorona-sűrűségére

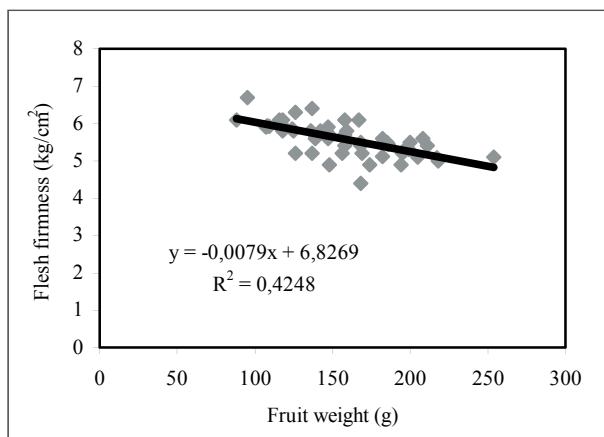


Figure 7: Relationship between fruit weight and flesh firmness by Jonathan Csány

7. ábra: A gyümölcstömeg és a húskeménység kapcsolata Jonathan Csány almafajta esetében

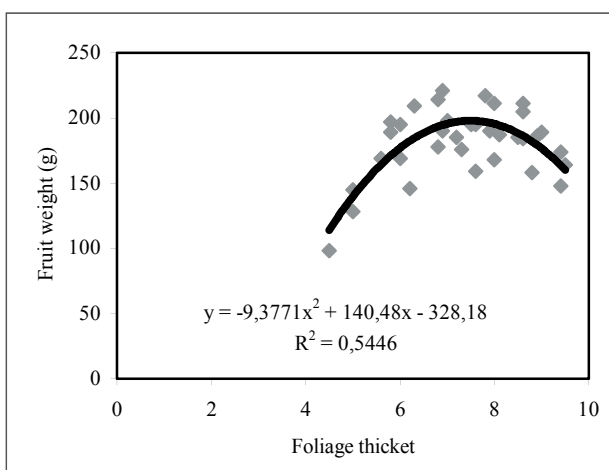


Figure 5: Relationship between foliage thicket and fruit weight by Jonathan Csány

5. ábra: A lombkorona-sűrűség és a gyümölcstömeg közötti kapcsolat Jonathan Csány almafajta esetében

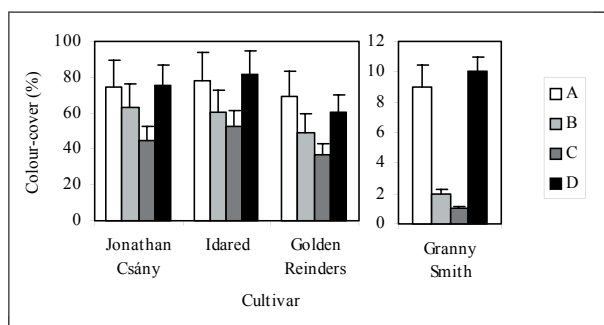


Figure 8: Effect of nutrient supply treatments on colour-cover of apple fruits

8. ábra: A tápanyagellátás kezelések hatása az almafajták fedőszín-borítottságára

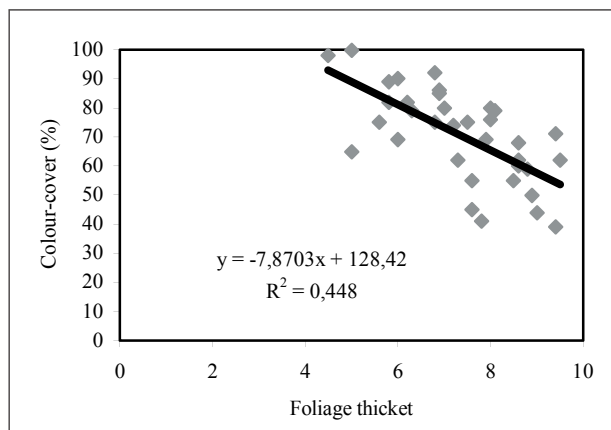


Figure 9: Relationship between foliage thicket and colour-cover of fruit by Jonathan Csány

9. ábra: A lombkorona-sűrűség és a fedőszín-borítottság kapcsolata Jonathan Csány almafajta esetében

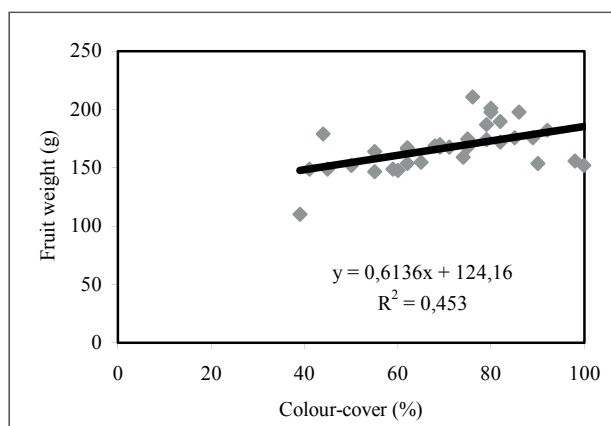


Figure 10: Relationship between colour-cover of fruit and fruit weight by Jonathan Csány

10. ábra: A fedőszín-borítottság és a gyümölcstömeg kapcsolata Jonathan Csány almafajta esetében

N-doses, because the highest experimental N-dose did not have enough effect to thicken the foliage too.

Also the flesh firmness is a fruit quality parameter. The consumers give preference – within a well-defined interval – the higher flesh firmness, this consider better quality.

By values of flesh firmness were observed differences under different nutrient supply levels: increasing N-doses have decreasing effect on flesh firmness (Figure 6). The decrease was express in especially by cultivars Jonathan Csány and Idared. By using combined macroelements we did not observed considerable decrease of flesh firmness.

Values ranged from control to treatment „B” (N_{50}). In the case of cultivar Granny Smith the flesh firmness came near to value of control.

Moreover we explored relationships between some fruit quality parameters. We established, that fruit quality was negative correlation with flesh firmness. This means fruit weight the larger, flesh firmness the lower. The correlation coefficient on the Figure 7 is not too high, but well defines the character and direction of this relation. It is worth taking this into consideration by storage, because flesh firmness will decrease by the end of storage (except ULO-storage).

Authors studied colour-cover of fruits too. Increasing N-supply was decreased the colour-cover, proportional to applied N-doses (Figure 8). In contrast with this, by applying NPK agents was not decreased values of this parameter highly than by pure nitrogen. Under influence of treatments, in the case of cultivar Jonathan Csány was similar to control, by Golden Reinders decreased and by Idared, Granny Smith increased the colour-cover (differences are significant). This increase is advantage by all of the most apple cultivars, but it is expressed disadvantage by Granny Smith. In the case of this cultivar the consumers claim the green colour on all of the fruit surface.

Similarly to establishment of Figure 7, negative correlation was demonstrated between thicket of foliage and colour-cover of fruits (Figure 9). This relation means, that thicked crown hinders – similar to fruit weight – the increase of colour-cover, and spoils the fruit quality. Perhaps this can be benefit for cultivar Granny Smith.

Colour-cover can be connected also with fruit weight. This relationship is positive and linear, that means fruit weight the larger, colour-cover the higher (Figure 10). This issues from the largest fruits can find on the upper part of crown and there them were exposed to high sunbeam. But this will often injurious, especially by reason of risk of sunburn [10].

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