SZENT ISTVÁN EGYETEM
GÖDÖLLŐ

SZIE Szarvasi Campusának kutatási és képzési profiljának specializálása intelligens szakosodással: mezőgazdasági vízgazdálkodás, hidrokultúrás növénytermesztés, alternatív szántóföldi növénytermesztés, ehhez kapcsolódó precíziós gépkezelés fejlesztése
EFOP-3.6.1-16-2016-00016

IV. ORSZÁGOS TRITIKÁLÉ NAP: „FÓKUSZBAN ÚJRA A TRITIKÁLÉ ZÖLDHASZNOSÍTÁSA”

CÍMŰ KONFERENCIA SZEKCIÓIBAN ELHANGZOTT TUDOMÁNYOS ELŐADÁSOK

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TARTALOMJEGYZÉK

ALTERNATÍV NÖVÉNYTERMESZTÉSI SZEKCIÓ

A TRITIKÁLÉ TERMESZTÉS BIOLÓGIAI ALAPJAI VETŐMAG ÉS FAJTA HELYZET

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Bevezetés

A hazai növénytermesztés színvonala, illetve annak gazdasági szerepe és súlya sok esetben jól jellemezhető a vetőmagtermesztés szintjével, annak szerepével és nemzetgazdasági súlyával. Azon országok, amelyek erős innovatív fejlesztésekkel, erős mezőgazdasággal rendelkeznek, ott kiemelkedő szerep jut a genetikai alapok fejlesztésének, a nemesítésnek és az egyre korszerűbb fajták termesztésbe vonásának. Jelenleg a kalászos gabonák termesztésén belül a tritikálé egy nagy termőterület növekedést mutató növényfaj, ahol igen sikeres termesztésről, és technológiai fejlesztésekről adhatunk számot. Azonban a termőterület növekedésén túl fontos annak az ismerete, hogy mennyire használnak korszerű fajtákat, illetve milyen szintű a vetőmagelőállítás szintje.

Irodalmi áttekintés

Hoffmann et al. (2001, 2002) cikkeikben arról számolnak be, hogy az 1998-2002 közötti időszakban kutatásba bevont magyar nemesítésű rozs és tritikálé genotípusok jó stressztűrő képességgel rendelkeznek, elsősorban szárazságtűrésre, vagy tápanyaghiányra, de egyes genotípusok mindkét tényezővel szemben.
Szabó (2018) megállapította, hogy a kalászos növények közül az Európai Uniós csatlakozásunk legnagyobb vesztese a rozs mellett az őszi tritikálé volt. A vetőmag-előállítási terület nagysága az elmúlt 5 évben emelkedésnek indult, a megnövekedett keresletnek köszönhetően. A Nemzeti Fajtajegyzék 19 fajtája közül 13 fajta, valamint a Közösségi Fajtakatalógusból további 16 fajta került szaporításra 2017-ben összesen 2590,98 hektáron.
Kruppa (1995) rozstermesztésről szóló cikkében kiemeli a középmagas és magas szárú hazai rozsfajták kitűnő alkalmazkodóképességét. Ezen fajták gyenge termékenységű homoktalajokon végzett kísérleteikben felülmúlták a külföldi (lengyel és német) fajták és hibridek termőképességét. A magánnemesítés eredményeként Állami Elismerésben és Növényfajta – oltalomban is részesült újabb magyar fajták; a Ryefood rozs és a Hungaro tritikálé étkezési - és takarmánygabona termesztésére is kiválóan alkalmasak és jó szárazság – és stressz tűrő képességgel rendelkeznek (Kruppa és Ifj. Kruppa, 2012).
Az őszi tritikálé vetőmag átlagtermése 4,84 t/ha volt 2017-ben, ez közel 300 kg/ha-al alacsonyabb, mint 2016-ban, így az összes termés 12.443 tonna volt, amely mintegy 2.200 tonnával volt kevesebb az előző évinél. A legkisebb hozamokat Komárom-Esztergom (2,76 t/ha), valamint Somogy (3,85 t/ha) megyében érték el. Kiemelkedő termésátlagokat értek el Baranya (7,25 t/ha), Békés (5,81 t/ha), Heves (5,70 t/ha) és Borsod-Abaúj-Zemplén (5,94 t/ha) megyék. (Szabó, 2018.)

Anyag és módszer

Dolgozatunkban a Nemzeti Élelmiszerlánc-biztonsági Hivatal Növénytermesztési és Kertészeti Igazgatóság adatbázisának, valamint a Megyei Kormányhivatalok vetőmag-felügyeleti tevékenységének adataiból készítettünk egy elemzést, amely jól reprezentálja a hazai tritikálé *(Triticosecale)*, és a hasonló szegmenst betöltő rozs *(Secale cereale)* hazai helyzetét és szerepét. Az érintett adatbázisok elemzésével elsősorban a vetőmag szegmens szerepét és a vetőmag előállítás adatait tudtuk elemzésünkbe emelni.
A dolgozat készítése során a fent említett adatbázisokon kívül támaszkodtunk a Nemzeti Agrárgazdasági Kamara és a KSH adatbázisaira is, amely a hazai növénytermesztés számadatait szolgáltatta. A két bázisból nyert adatok segítségével lehetőségünk volt elemezni a növénytermesztésen belüli abszolút helyzetét a tritkálénak, illetve a növénytermesztési ágazaton belül a vetőmagelőállítás, a fajtaszortiment, a fajtahasználat nagyságrendjét.

Eredmények és értékelésük

A magyarországi vetésszerkezetben a kalászos gabonák szerepe megkérdőjelezhetetlen, amelyet jól mutat, hogy 2018-ban a kalászos gabonák összes vetésterülete 1.393 ezer ha volt, amely több mint a teljes szántóterület 32%-a. Ezen belül természetesen a legnagyobb területet az őszi búza foglalja el, majd az őszi árpa következik és a harmadik legnagyobb területen termesztett kalászos gabona az utóbbi 7 évben.

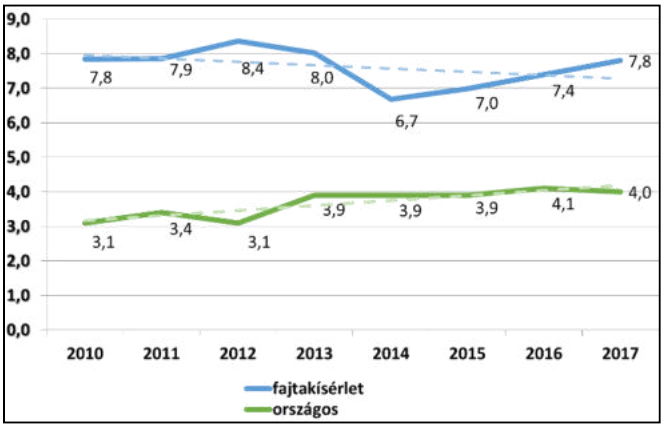
1. táblázat A kalászosok vetésterülete Magyarországon 2010-2018.

Faj (1)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
	Vetésterület (eha)								
Búza (2)	1 011	978	1 070	1 090	1 113	1 029	1 044	958	955
Rozs (3)	37	33	35	35	34	37	27	26	27
Őszi árpa (4)	185	159	176	189	206	220	267	237	231
Tavaszi árpa (5)	96	102	99	73	82	76	46	56	48
Zab (6)	51	54	53	51	51	45	36	36	35
Tritikálé (7)	120	101	111	118	123	128	114	94	97

Table 1. Harvested area of cereals in Hungary 2010-2018. (1) Species, (2) Whinter wheat, (3) Secale, (4) Winter Barley, (5) Spring Barley (6) Oats, (7) Triticale

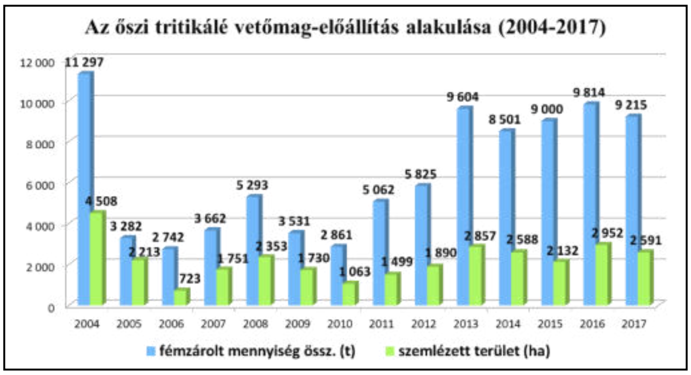
forrás: KSH és NAK, 2018.

A hazai tritikálé termesztésben nagyon nagy potenciális lehetőségek vannak, melyet igen jól jellemez a hazai köztermesztésben elért termésátlagok és a fajtakísérleti terméseredmények között mért különbség. Az utóbbi nyolc évben a köztermesztésben és a fajtakísérletekben elért terméseredmények közt a különbség csökkent ugyan, de még mindig nagy a potenciális lehetőség a hozamok növelésére. Az elmúlt években a legkisebb különbséget 2014-ben értünk el, de még ebben az évben is mintegy 2,8 t/ha-al nagyobb hozamokat értek el a tritikálé fajták a fajtakísérletekben, mint a köztermesztés során. Ez azt jelenti, hogy a fajtakísérletekben a tritikálé fajták mintegy 41,8 – 63,1%-kal nagyobb hozamot értek el. A köztermesztésben tehát a fajtákban rejtő potenciális lehetőségeket, mintegy fele arányban használjuk csak ki, amelyet az agrotechnika javításával, a megfelelő fajtaválasztással illetve a fajtaspecifikus termesztéstechnológiák alkalmazásával lehetne javítani.



1. ábra Az őszi tritikálé termésátlaga Magyarországon és a fajtakísérletekben
Figure 1. Yields of winter triticale in Hungary and variety experiments

Egy adott növényfaj szerepét a hazai köztermesztésben betöltött szerepén túl jól jellemez a növényfaj vetőmag-előállítási volumene *(2. ábra)*, az hogy a termesztésben mekkora hangsúllyal szerepel a fémzárolt vetőmag és a modern új fajták, új genotípusok termesztése.



2. ábra Az őszi tritikálé vetőmag előállítása Magyarországon
Figure 2. Winter triticale seed production in Hungary

A vizsgált időszakban jól megfigyelhető, hogy az utóbbi években (2010-től) fokozatosan nőtt a tritikálé vetőmag-termő terület nagysága, amely elérte a 2,1-2,9 ezer ha körült területet. Ennek megfelelően a fémzárolt vetőmag mennyisége is nőtt, az utóbbi években tartósan 9-9,8 ezer tonna körül alakult. Ez elsősorban a megnövekedett keresletnek köszönhető, ugyanis megjelentek az új felhasználási irányok (szilázs, malomipari felhasználás stb.) a tritikálé termesztésében az eddigi takarmány célú hasznosítás mellett.

2. táblázat Az államilag elismert tritikálé fajták száma 2018. évben

Faj (1) (őszi+tavaszi)	Nemzeti Fajtajegyzék	Közösségi Fajtakatalógus
Búza (2)	162 + 5	2488
Árpa (3)	57 + 45	1427
Durumbúza (4)	8 + 1	538
Zab (5)	7 + 12	361
Tritikálé (6)	18 + 1	332
Rozs (7)	6	198
Tönkölybúza (8)	6	61
Csupasz zab (9)	1	38

Table 2. Number of triticale varieties in 2018. (1) Species, (2) Whinter wheat, (3) Barley, (4) Durum wheat, (5) Oats (6) Triticale, (7) Secale, (8) Spelled wheat, (9) Bare oats (10) National Catalog of Varieties, (11) European Union Catalog of Varieties

forrás: NEBIH, 2018.

A tritikálé fajták száma is jól jellemzi a hazai termesztésben betöltött szerepét *(2. táblázat)*. A legnagyobb vetésterülettel rendelkező búza igen sok államilag elismert fajtával rendelkezik, a Nemzeti Fajtajegyzékben 2018-ban mintegy 162 őszi és 5 tavaszi vetésű búzafajta szerepelt. Az őszi vetésű kalászosok közül az árpa fajták után a tritikálé fajták száma a legnagyobb, ami a vetésterületi szereppel megegyező rangsort mutat. A Nemzeti Fajtajegyzékben 2018-ban 18 államilag elismert őszi tritikálé fajta és egy tavaszi fajta szerepelt. Az Európai Unió Közösségi Fajtakatalógusában szereplő fajták között is az erős középmezőnyben szerepel a tritikálé, mintegy 332 fajta szerepel a katalógusban. Ez is azt mutatja, hogy egy dinamikusan fejlődő, erősödő szereppel rendelkező növényfaj lett a tritikálé az elmúlt évtizedekben, mind a hazai, mind pedig az európai termesztési területeken.

3. táblázat Az államilag elismert tritikálé fajták aránya hazai/EU 2018. évben

<table>
<tr><th colspan="5">Nemzeti Fajtajegyzék (1)</th><th rowspan="2">Közösségi Fajtakatalógus (2)</th></tr>
<tr><th colspan="3">őszi (3)</th><th colspan="2">tavaszi (4)</th></tr>
<tr><td>össz (db) (5)</td><td>hazai (db) (6)</td><td>EU (db) (7)</td><td>össz (db) (5)</td><td>hazai (db) (6)</td><td>összesen (db) (5)</td></tr>
<tr><td>18</td><td>14</td><td>4</td><td>1</td><td>1</td><td>332</td></tr>
</table>

Table 3. Rate of triticale varieties national/EU in 2018. (1) National Catalog of Varieties, (2) European Union Catalog of Varieties, (3) whinter, (4) spring, (5) summa, (6) national, (7) EU

A fajták nemesítése szintén egy jellemzője az adott növényfaj gazdaságon belül betöltött szerepének. Ha a hazai nemesítés erős, és a fajták versenyképesek, akkor a Nemzeti Fajtajegyzékben dominál a hazai nemesítésű fajták aránya. Az őszi vetésű tritikálé fajták esetében kijelenthető, hogy megfelelő a hazai nemesítésű fajták aránya, a 18 államilag elismert fajtából 14 db hazai nemesítésű, ami azt mutatja, hogy a hazai nemesítés erős, versenyképes a nemzetközi nemesítőházak fajtáival. Külön kiemelendő, hogy a hazai nemesítésű 14 fajta közül 3 étkezési minősítésű, amely jól mutatja a megváltozott fogyasztói igényeket és az ahhoz való nemesítői alkalmazkodást. A képet árnyalja kissé, hogy a Közösségi Fajtakatalóguson szereplő mintegy 332 fajta is erőteljesen megjelenik a vetőmag szaporító területekben, annak aránya ott már nem ennyire kedvező.

Az új fajták elismerése is dinamikus Magyarországon, a NÉBIH fajtakísérleteiben 7 új fajtajelölt (5 hazai és 2 EU) szerepelt 2017-2018. évben, amelyből 1 fajtát étkezési fajtaként szeretnének elismertetni. Ez azt mutatja, hogy a genetikai állománya jó a növényfajnak, alkalmas újabb és újabb fajták szelekciójára, nemesítésére.
Szintén a fajtakísérleti állomásokon megfigyelt tapasztalat, hogy az eddig ellenállónak hitt, és kevés gombabeteggel fertőződő növényfajnak tűnt a tritikálé, 2015/2016 évben 3 kísérleti helyen is erőteljesen fertőződtek egyes fajták a sárgarozsda „triticale" rasszával, amely 2017-ben Eszterágpusztán, majd 2018-ban Szarvason és Gyulatanyán is megismétlődött. Ez arra utal, hogy az új modern tritikálé fajták esetében valószínűleg a jövőben nem lesz elkerülhető a fungicides védekezés a köztermesztésben.

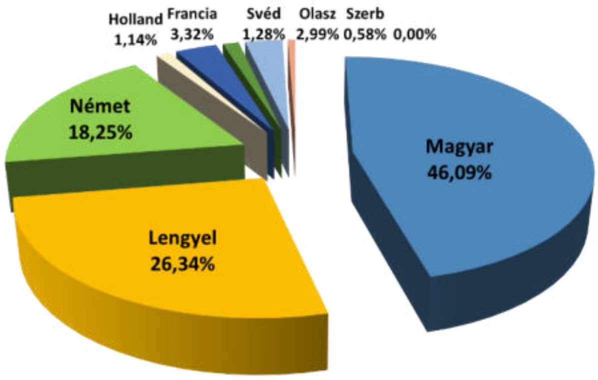
4. táblázat Az államilag elismert tritikálé fajták rangsora és aránya

2017	**2016**	**2015**	**2014**	**Fajta (1)**	**2014**	**2015**	**2016**	**2017**
rangsor (2)					**%**			
1.	2.	2.	1.	**Leontino (PL)**	19,45	21,98	15,02	15,30
2.	1.	1.	2.	**GK Szemes (H)**	18,45	25,12	18,99	13,91
3.	12.	21.	25.	**GK Maros (H)**	0,02	0,52	2,70	9,88
4.	4.	8.	-	**SU Agendus (D)**	-	2,64	8,27	8,85
5.	3.	4.	6.	**Hungaro (H)**	6,89	7,35	12,18	8,04
6.	29.	-	-	**Salto (PL)**	-	-	0,10	3,86
7.	27.	17.	-	**Cosinus (D)**	-	0,99	0,17	3,63
8.	-	10.	-	**Amarillo 105**	-	2,14	-	3,54
9.	13.	-	8.	**Trismart (PL)**	2,97	-	2,69	3,36
10.	7.	6.	7.	**Titan (H)**	4,24	4,36	3,75	3,28
11.	15.	-	-	**Altair (I)**	-	-	1,96	2,99
12.	5.	3.	5.	**GK Rege (H)**	7,67	9,68	5,49	2,78

Table 4. Rank and Rate of triticale varieties (1) Variety, (2) Rank

A tritikálé fajták vetőmag szaporító területeinek, valamint a megtermelt vetőmag mennyiségének ismeretében az államilag elismert fajták között kialakítható egy olyan rangsor amely szoros korrelációt mutat az adott fajta vetésterületével, annak termesztésben elfoglalt helyével *(4. táblázat)*. Minél nagyobb területen állítják elő egy fajta vetőmagját annál nagyobb szerepe van a szántóföldi növénytermesztésben. Ha egy fajta régi, korszerűtlen és az új genotípusok teljesítménye mellett nem versenyképes, akkor azok a fajták veszítenek jelentőségükből, így egyre kisebb lesz a fajtából előállított vetőmag mennyisége is.
A hazai őszi tritikálé vetőmag előállításban már évek óta két fajta a Leontino (PL) és a GK Szemes uralja felváltva az 1. és a 2. helyet a fajták rangsorában. Az utóbbi évek sikerfajtája a GK Maros, amely 2014-ben még csak a 25. volt a rangsorban, de 2017-ben már a 3. helyet foglalta el a termesztett fajták rangsorában. A szintén magyar nemesítésű Hungaro fajta kiegyenlítetten a középmezőnyben foglal helyet, ez mutatja, hogy a fajta rendkívül stabil, kiegyenlített teljesítményt nyújtó, kiváló alkalmazkodó képességű fajta. Megfigyelhető azonban, hogy a külföldi fajták (Salto, Cosinus) erőteljesen törnek előre,

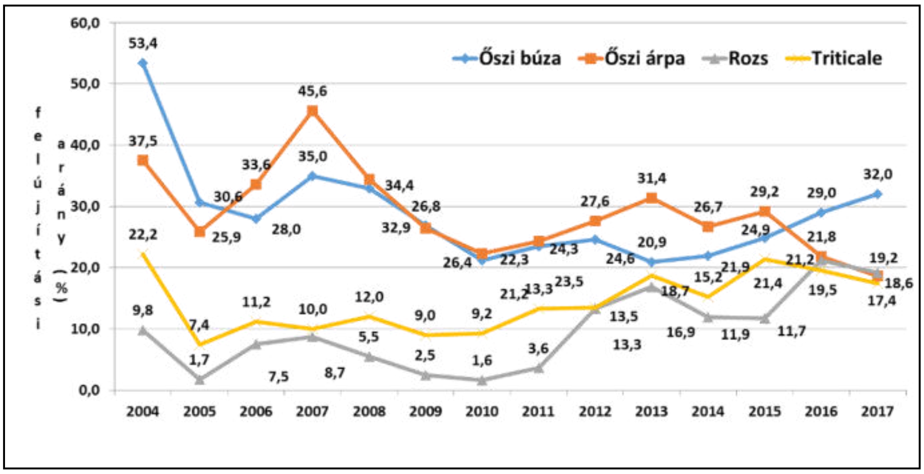
a termesztésük egy-két évvel ezelőtt még nem folyt, de ma már az igen előkelő 6. és 7. helyet foglalják el a rangsorban. A külföldi fajták térnyerése, előretörése a jövőben veszélyeztetheti a magyar nemesítésű fajtákat, viszont jelenthet egy erőteljesebb versenyhelyzetet is, ami még jobb fajták megjelenésével járhat.



3. ábra Az őszi tritikálé fajták származás szerinti aránya a szaporító terület alapján 2017-ben
Figure 3. Rate of winter triticale varieties based on reproductive area in 2017.

A külföldi fajták térnyerése jól nyomon követhető a szaporítóterületek alapján is *(3. ábra)*. Jól látható, hogy a magyar fajták már nem érik el a terület 50%-át (46,09%), de még mindig a legmeghatározóbb a szerepük a hazai tritikálé vetőmagtermesztésben. A magyar nemesítésű fajtákat az őszi tritikálé területén a lengyel, majd a német nemesítésű fajták területei követik, a lengyel és a német nemesítésű fajták területi aránya 44,59%, amely már megközelíti a magyar fajták területét. Más országokból származó (holland, francia, svéd, olasz, szerb) fajták területi aránya rendkívül kicsi, 0,58-3,32 % körül alakul.

Egy növényfaj (pl. kalászos gabonák) termesztésének színvonalát meghatározza a fajták ún. felújítási aránya. A felújítási arány azt jelenti, hogy az adott évben a teljes termőterület hány %-án termesztenek fémzárolt vetőmagot. A modern fajtákat, új genotípusokat felhasználó korszerű gazdálkodás megköveteli, hogy a lehető leggyakrabban fémzárolt vetőmagot vessenek a gazdálkodók. Hibrid fajták esetén (pl. kukorica, napraforgó) a gazdák szinte 100%-ban minden évben fémzárolt vetőmagot vetnek, az új genotípusok terjedése ezért gyors, a hozamok növekedése országos szinten is folyamatos. Az öntermékeny fajták esetében (pl. kalászos gabonák) ez a felújítási arány erősen függ a gazdálkodók szakmai felkészültségétől, tudásától, az anyagi helyzetétől, a gazdálkodás színvonalától. A hazai növénytermesztésben a kalászosok felújítási aránya lényegesen elmarad az elvárható szinttől *(4. ábra)*. A 2005-ös évhez viszonyítva az őszi árpa felújítási aránya jelentősen csökkent, az őszi búza egy komoly csökkenést követően 32% volt 2017-ben, míg a rozs és a tritikálé felújítási aránya növekedést mutat, de még mindig rendkívül alacsony, nem éri el a 20%-ot. 19,2% és 17,4%.



4. ábra A legjelentősebb kalászos gabonák felújítási aránya 2017-ben
Figure 4. Renewal rate of the most important cereals in 2017.

Ezek a számok azt mutatják, hogy Magyarországon még mindig igen lassú az új genotípusok termesztésbe vonása, igen erőteljes egy fajtának esetenként az újravetése, amely a fajta leromlását, a termőképesség és az ellenálló képesség csökkenését eredményezheti. A tritikálé fajták esetében például a gazdálkodók átlagban csak minden 5. évben vásárolnak fémzárolt vetőmagot, amely rendkívül rossz termelői gyakorlat. Többek közt ez is hozzájárul ahhoz, hogy a köztermesztésben termesztett fajták termésátlaga jelentősen eltér a fajtakísérletekben mért termésátlagoktól *(1. ábra)*. A kalászos gabonák közül az őszi búza felújítási aránya a legjobb (32%), de ez is azt jelenti, hogy három évente vásárolnak csak a területre fémzárolt, kiváló genetikával rendelkező vetőmagot. A jövőben ezt mindenképpen javítani szükséges a hazai növénytermesztési gyakorlatban.

Következtetések

A tritikálé fajták és a vetőmagtermesztés helyzetének elemzésével megállapítottuk, hogy a tritikálé hazai nemesítése sikeres, a fajtaellátottság megfelelő. A hazai nemesítésű fajták mellett azonban erőteljes a külföldi nemesítésű fajták jelenléte, elsősorban lengyel és német fajták vannak a hazai termesztésben. A hazai fajták térnyerése érdekében szükséges:

- a magyar fajták versenyképességének javítása, új fajták termesztésbe vonása
- a tritikálé fajták felújítási arányának növelése

Amennyiben a gazdálkodók javítanak az eddigi kevesebb mint 20%-os felújítási arány alkalmazásán, akkor a hazai tritikálé termésátlagok növelése biztosítható. Természetesen a fajták igényeinek megfelelő fajtaspecifikus termesztéstechnológiák bevezetése, valamint annak folyamatos K+F fejlesztése tovább tudja javítani a növény termesztésének hatékonyságát.

Összefoglalás

A tanulmányunkban a NÉBIH NKI, valamint a NAK adatbázisai alapján elemeztük a hazai tritikálé termesztés biológiai alapjait, a fajta ellátottságot, valamint a vetőmagtermesztés helyzetét, eredményeit.
Megállapítottuk, hogy az őszi tritikálé fajta ellátottsága megfelelő, jelentős a hazai nemesítésű fajták aránya. A fajták termőképessége jó, azonban a hazai köztermesztés termésátlagai jelentősen (41,8-63,1%-al) elmaradnak a fajtakísérletek eredményeitől. Ez arra utal, hogy még jelentős tartalékok vannak a termesztéstechnológia fejlesztésében a hazai termesztésben.
Az elemzés során megvizsgáltuk a hazai vetőmagtermesztés helyzetét. A vetőmag termő területek nagysága az utóbbi években növekedik 2,6-2,9 ezer ha, a növekvő fogyasztói igényeknek köszönhetően (pl. malomipar, gabonaszilázs stb.). Az előállított vetőmag mennyisége is növekszik, mintegy 9,2-9,8 ezer tonna évente.
A fajták és a vetőmagtermesztés eredményeit összevetettük a felújítási arányokkal, és megállapítottuk, hogy az utóbbi években javul ugyan a tritikálé fajták felújítási aránya, de még mindig nem éri el a 20%-ot, ami igen kedvezőtlen.
Javasolható ezért új hazai nemesítésű fajták termesztésbe vonása, illetve a felújítási arány növelése.

Kulcsszavak: fajta, tritikálé, vetőmag

Köszönetnyilvánítás

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BIOLOGICAL BASIS OF TRITICLE PRODUCTION, POSITION FOR SEEDS AND VARIETIES

Abstract

In our study we analyzed the biological bases of national triticale cultivation on the basis of NKIBI NKI and NAK databases, the variety of supply, and the position and results of the seed production. We have found that the winter triticale variety supply is adequate, the rate of national breed varieties is high.

The yields of the varieties are good, however, the yields of triticale production in Hungary fell significantly (41.8-63.1%) from the results of the varietal experiments. This indicates that there are still substantial reserves in the development of cultivation technology.
During the analysis, we investigated the situation of seed production in Hungary. The volume of seed production areas increase in recent years 2.6-2.9 thousand ha, due to increasing consumer demands (eg milling, silage etc.). The amount of seed produced is also increasing, about 9.2-9.8 thousand tons per year.
We have found that in recent years the renewal rate of triticale varieties is improving, but it still does not reach 20%, which is very unfavorable.
It is therefore recommended to grow new national breeding varieties and to increase the rate of renewal.

Keywords: variety, triticale, seed

A KRUPPA-MAG KUTATÓ KFT. FAJTÁI A SZILÁZS ELŐÁLLÍTÁSBAN

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Bevezetés

A hazai növénytermesztés ágazatai változó mértékben vannak kitéve a klímaváltozás várható hatásainak. Az ökológiai tényezők (éghajlat és talaj) rendkívül kedvezők Magyarországon a legtöbb növény termesztése szempontjából. Igen nagy a szántóterületek aránya, valamint a szántóterületeken belül a jobb minőségű területek nagysága is. A térséget a csökkenő csapadékmennyiséggel, és hosszabb száraz periódusokkal tarkított klímahatás jellemzi. A klímaváltozás előrejelzései, prognózisai alapján a kalászos gabonafélék és a lucerna tömegtakarmány termesztéséhez az éghajlatunk és talajadottságaink kiválóak és a közeljövőben ezt a klímaváltozás sem veszélyezteti! Ezért igen nagy a kalászosok vetésterületi aránya a hazai vetésszerkezetben.
A Nemzeti Fajtajegyzékben szereplő - elsősorban magyar nemesítésű fajták – és az abból itthon előállított vetőmagvak kiváló biológiai alapokat biztosítanak a tömegtakarmány termesztéshez! A külföldön nemesített fajtákban nagy lehet a kockázat elsősorban télállóság, betegség ellenállóság, termés vonatkozásában!
Az agrotechnika, technológia kérdésköre igen széles a tömegtakarmányok termesztésében. A növényi sorrend kialakítása, vetésváltás, talajművelés, tápanyagellátás, növényápolás, növényvédelem, öntözés, betakarítás (kaszálás, rendkezelés stb.) és a postharvest technológia (silózás) jelenthet kiváló eredményt és nagy kockázatot is, amely elsősorban a szakmai felkészültségtől, a szakemberek technológiai tudásától függ. Dolgozatunkban arra keressük a választ, hogy a hazai nemesítésű fajták meg tudnak –e felelni a klímaváltozás és a csökkenő vízkészletek okozta kihívásnak.

Irodalmi áttekintés

Hoffmann et al. (2001, 2002) cikkeikben arról számolnak be, hogy az 1998-2002 közötti időszakban kutatásba bevont magyar nemesítésű rozs és tritikálé genotípusok jó stressztűrő képességgel rendelkeznek, elsősorban szárazságtűrésre, vagy tápanyaghiányra, de egyes genotípusok mindkét tényezővel szemben.
Szabó (2018) megállapította, hogy a kalászos növények közül az Európai Uniós csatlakozásunk legnagyobb vesztese a rozs mellett az őszi tritikálé volt. A vetőmag-előállítási terület nagysága az elmúlt 5 évben emelkedésnek indult, a megnövekedett keresletnek köszönhetően. A Nemzeti Fajtajegyzék 19 fajtája közül 13 fajta, valamint a Közösségi Fajtakatalógusból további 16 fajta került szaporításra 2017-ben összesen 2590,98 hektáron.
Kruppa (1995) rozstermesztésről szóló cikkében kiemeli a középmagas és magas szárú hazai rozsfajták kitűnő alkalmazkodóképességét. Ezen fajták gyenge termékenységű homoktalajokon végzett kísérleteikben felülmúlták a külföldi (lengyel és német) fajták és hibridek termőképességét. A magánnemesítés eredményeként Állami Elismerésben és

Növényfajta – oltalomban is részesült újabb magyar fajták; a Ryefood rozs és a Hungaro tritikálé étkezési - és takarmánygabona termesztésére is kiválóan alkalmasak és jó szárazság – és stressz tűrő képességgel rendelkeznek (Kruppa és Ifj. Kruppa, 2012).
Az őszi tritikálé vetőmag átlagtermése 4,84 t/ha volt 2017-ben, ez közel 300 kg/ha-al alacsonyabb, mint 2016-ban, így az összes termés 12.443 tonna volt, amely mintegy 2.200 tonnával volt kevesebb az előző évinél. A legkisebb hozamokat Komárom-Esztergom (2,76 t/ha), valamint Somogy (3,85 t/ha) megyében érték el. Kiemelkedő termésátlagokat értek el Baranya (7,25 t/ha), Békés (5,81 t/ha), Heves (5,70 t/ha) és Borsod-Abaúj-Zemplén (5,94 t/ha) megyék. (Szabó, 2018.)

Anyag és módszer

Dolgozatunkban a Kruppa-mag Kft. által nemesített rozs, tritikálé és lucerna fajták tömegtakarmány termesztésének eredményeit dolgozzuk fel, Szarvasi kísérletek eredményeit bemutatva. A kísérletek adatbázisát ezen felül azok az országos kísérletek is szolgáltatják, amelyek tömegtakarmány előállító gazdaságok termesztési adataiból állnak össze. A kísérleti adatok nagy száma biztosítja annak reprezentatív jellegét.
A vizsgált fajták termőképességét, hozamait összevetettük a konkurens tömegtakarmányok hozamaival, értékeltük annak betakarítási idejét, és elemeztük annak a hazai klímában elfoglalt helyzetét (mennyire előzi meg az aszályos periódust, milyen vízmennyiséget használ fel, mekkora konkurens tömegtakarmány hozammal egyenértékű a termesztés? stb.).
A dolgozat készítése során elemeztük a tömegtakarmányok hozamain kívül a takarmányok beltartalmi értékeit, azok takarmányértékét is vizsgáltuk.

Eredmények és értékelésük

A Nemzeti Éghajlatváltozási Stratégia 2014-2025, kitekintéssel 2050-re, elemzése szerint jelentős változások várhatóak a hőmérsékletek alakulásában. Jellemzően a fagyos napok számának csökkenésével, és a meleg napok számának növekedésével számolhatunk 2100-ig *(1. táblázat)*.

1. táblázat A hőmérsékleti szélsőségek várható alakulása Magyarországon
(ELTE, Meteorológiai Tanszék, 2013. szeptember NÉS)

extrém hőmérsékleti indexek	átlagos érték (nap)	várható változás (nap)	
	1961–1990	2021–2050	2071–2100
Fagyos napok száma (Tmin < 0 °C)	93	-35	-54
Nyári napok száma (Tmax > 25 °C)	67	38	68
Hőségnapok száma (Tmax > 30 °C)	14	34	65
Forró napok száma (Tmax > 35 °C)	0,3	12	34
Hőségriadós napok száma (Tközép > 25 °C)	4	30	59

Table 1. Expected changes in temperature extremes in Hungary

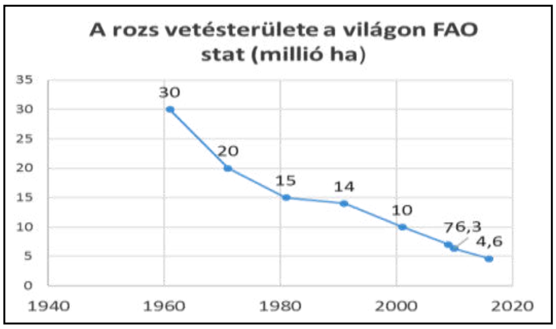
forrás: ELTE, NÉS

A felmelegedés miatt nagyobb mértékű az evapotranszspriráció, amely a nyári félévben növeli a vízhiányt és kockázatosabbá teszi a nagy vízigényű növényfajok öntözés nélküli termesztését.

Csapadékellátottság és eloszlás tekintetében sem jeleznek a prognózisok kedvező képet a növénytermesztés számára. A száraz periódusok (<1 mm) maximális hosszának várható változása az 1961-1990. időszakhoz képest eltérő a téli és a nyári félévben. Télen +15-20% csapadék, amely egyben azt is jelenti, hogy az egymást követő száraz napok száma a század végére 10-15%-kal csökkenhet. Ez azt mutatja, hogy egy csapadékosabb téli félévben felértékelődik a vegetációs időszakon kívüli víz tárolása, visszatartása a talajokban.
Nyáron ezzel szemben -10-30%-kal kevesebb a lehullott csapadék mennyisége, az egymást követő száraz napok száma a század végére 15-25%-kal növekedhet a Dunától keletre, az Alföld területein, ahol a legnagyobb szántóterületek, és növénytermesztési szempontból kiemelkedő területek találhatók.
A tenyészidőszak kevesebb csapadéka és a száraz időszakok hosszának növekedése – a hőmérséklet emelkedéssel együtt – még tovább fokozza a vízhiányt, ami öntözetlen körülmények között ellehetetleníti a nagy vízigényű tömegtakarmány növények pl. a silókukorica termesztését!

Alkalmazkodás a klímaváltozáshoz a tömegtakarmány termesztésben – mi lehet a megoldás?

Tömegtakarmány termesztésünket (szilázs, szenázs) nagyobb biztonsággal és kisebb költséggel alapozhatjuk az őszi kalászos gabonafélékre (elsősorban rozs és tritikálé). A gabonafélékből készített szilázs mind hozamban, mind minőségben versenyképes a nagy vízigényű növényfajokból (silókukorica) készített szilázzsal.
Ezek kis vízigényű - a többi gabonafélénél igénytelenebb - növényfajok (fajták) a nagyobb valószínűséggel rendelkezésre álló téli félév csapadékával (+kevés tápanyaggal) vegyszermentesen, környezetbarát technológiával és biztonságosan termeszthetők (+terület felhasználása nélkül). A betakarítás (kaszálás áprilisban) után még vetni lehet (siló)kukoricát, napraforgót, cirkot, kölest, szóját stb.)



1. ábra A rozs vetésterülete a világon (millió ha)
Figure 1. Growing area of rye *(Secale cereale)* in the world FAO stat (million ha).

A világon a rozs vetésterülete folyamatosan csökken *(1. ábra)*, amely elsősorban a faj kicsi genetikai termőképességének köszönhető. A rozs kiválóan hasznosítja a gyenge termőképességű területeket, nagy zöldtömeget ad, de a szemtermése a nagy szár és levéltömeg ellenére kicsi. A világon visszaszorulóban van a termesztése, elsősorban tömegtakarmányként, és szemtermését humán célú és állati takarmányként hasznosítják.

A klímaváltozás hatásainak mérséklésére kiváló alternatíva lehet a különböző lucerna fajok termesztésének előtérbe kerülése is. A lucerna ugyan nagy víz-és tápanyagigényű, ennek ellenére a magyar fajták kiváló alkalmazkodóképessége, szárazságtűrése és télállósága révén – jó vízgazdálkodású talajainkon - öntözés nélkül is biztonságosan és eredményesen termeszthetők. A tarkavirágú *(M. varia)* fajták homokon is szépen díszlenek, a termesztésük gyengébb adottságú területeken is eredményes. A technológia során azonban nagyobb figyelmet érdemelne a jó minőségű széna készítés is, a 3. és a 4. növedék jobb hasznosítása, illetve a kiváló minőségű speciális géprendszer használata.

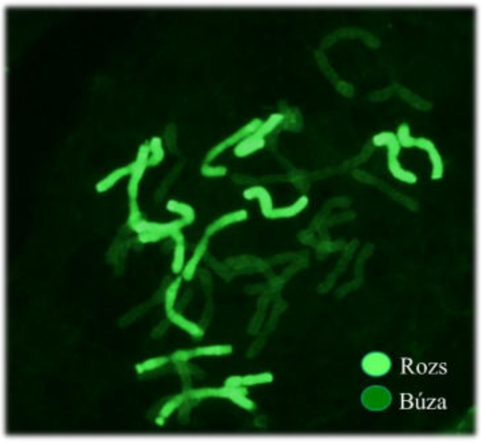
A rozzsal ellentétben a tritikálé szerepe a világon növekvő tendenciát mutat. A világon a tritikálé vetésterülete jelenleg eléri a 4,4 millió hektáros termesztési területet, amely az 1990-es években alig érte el a 0,8 millió hektáros vetésterületet. A növény ilyen gyors, lendületes térnyeréséhez elsősorban a faj jó alkalmazkodóképessége, a nagyobb termőképessége, kiváló beltartalma, valamint az utóbbi években előtérbe kerülő kiváló tömegtakarmány célú hasznosítása játszik szerepet. A tritikáléból készített gabonaszilázs kiváló alternatíva a kukoricaszilázzsal szemben, de azt kevesebb víz felhasználásával, a száraz periódusokat megelőzve képes szolgáltatni.
Nem hanyagolható el az a szempont sem, hogy a szilázsként történő korai betakarítás a termelő számára lehetőséget teremt arra, hogy az áprilisban felszabaduló területen késő tavaszi vetésű növény termesztését (kukorica, napraforgó, szója stb.) valósítsa meg. Ezzel a terület kihasználása jelentősen javítható, a takarmányellátás biztonsága mellett.

2. ábra A tritikálé vetésterülete a világon 1980-2020.
Figure 2. Growing area of triticale in the world 1980-2020.

A tritikálé, mint új tömegtakarmány - kitekintés a világba, és Magyarországra

A tritikálé tömegtakarmány célú termesztése a világon egyre nagyobb arányban jelenik meg a termőterületben. Az őszi tritikálét tisztán (nem keverékben) az USA délkeleti részén és Kaliforniában kb. 100 ezer ha-on silázsnak is termesztik. Ausztráliában jelentős a zöldhasznosítása – főként a száraz és gyenge termékenységű területeken. Algériában (Afrika) a tritikáléval a kukorica importot váltják ki – elsősorban tömegtakarmány (silázs, szenázs, zöldtakarmány) termesztéssel. A CIMMYT –ben (Mexico) nemesítik „zöldhasznosításra" is és szarvasmarhával etetik. Kanadában silázst készítenek belőle, Olaszországban zöld keverékekben hasznosítják.
Magyarországon is elkezdődött a tritikálé tömegtakarmány célú (silázs) termesztése, hasznosítása, az első évek eredményei biztatók. Kísérleteket végeztünk Szarvason a Szegedi Gabonakutató, a Kruppa-Mag Kft. és az Állattenyésztési Teljesítményvizsgáló Kft. bevonásával. A kutatás célja az optimális mennyiségi és minőségi tömegtakarmány paraméterekhez igazodó technológia fejlesztése, kutatása Magyarországi viszonyok közt.

A tritikálé zöldhasznosításának kísérleteibe elsőként bevont fajta a Hungaro nevű tritikálé fajta volt. A fajta főbb tulajdonságai a következők: Hexaploid *(3. ábra)*, közepes-magas szalmamagasságú, öntermékenyülő őszi fajta. Termőképessége 6-8 t/ha szemtermés, vagy 20-25 t/ha silázshozam (30-40% sz.a.) 20-25% fehérjével és 22-25% nyersrost tartalommal (70-76% rost lebonthatóság). A szemnek is magas a fehérje (14-16%) - és sikértartalma (16-28%), a tritikálé fajták közül a legjobb sütőipari tulajdonságokkal rendelkezik, lisztminősége: B1, B2. 2-3-szor több rost és ásványi anyag: P, K, Ca, Mg, Zn, Cu, több esszenciális aminosav: metionin, cisztein, (lizin) és vitamin E, B1, B2, B6), ami az állati takarmányozás szempontból is fontos! Lisztharmattal szemben rezisztens, rozsda ellenállósága jó, gyomelnyomó képessége kitűnő, fuzáriummal szemben a búzáknál ellenállóbb, ökológiai termesztésre is kiválóan alkalmas fajta.



3. ábra A Hungaro hexaploid tritikálé kromoszómái
Figure 3. The chromosomes of Hungaro hexaploid triticale (Rozs means Rye, Búza means Wheat)

Másik tömegtakarmányként vizsgált gabona a rozs volt. Abból is a Ryefood rozsfajtát vontuk be a kísérleteinkbe. A fajta főbb jellemzői: étkezési és takarmány (abrak és szilázs) rozsfajta. Diploid, szabadelvirágzású őszi fajta. Idegentermékenyülő. Magas fehérje- tartalmú fajta, amely alkalmas étkezési gabona, takarmánygabona és zöldtakarmány (szilázs) termesztésére egyaránt. Lisztjéből önmagában is jó minőségű rozskenyér süthető. Gyenge termékenységű- és homoktalajokon a legnagyobb termésre képes fajta. A belőle kalászolás előtt készült szilázs takarmány értéke kiváló: nyersfehérje tartalma (fehérje:18-21 %), szerves anyag- és rost emészthetősége (72-78%), energiatartalma: 6 MJ. Rozs szilázs kategóriában országosan a legjobb minőséget adja! Korán (április közepe) biztosít kiváló minőségű tömegtakarmányt (szilázs) és betakarítása (kaszálása) után még tavaszi növények (siló) kukorica, napraforgó stb.) vethetők.

2. táblázat A rozs szilázs takarmányértéke

Minőségi mutatók (1)	**Országos átlag (2)**			**Legjobb nagyüzemi eredmény *(Ryefood)* (3)**		
	2014	**2015**	**2016**	**2014**	**2015**	**2016**
Nyersfehérje (g/kg szárazanyag) (4)	132	133	143	192	191	185
NDFd (rostemészthetőség %) (5)	65	63	68	77	73	73
OMd (sz.a. emészthetőség %) (6)	71	69	72	81	78	77

Table 2. The feed value of rye silage, (1) quality indicators (2) national average (3) Best plant result (Ryefood), (4) crude protein (g/kg dry mass), (5) NDFd fiber digestibility %, (6) OMd (organic material digestibility %)
forrás: ÁT Kft. Hírlevél (2017 február).

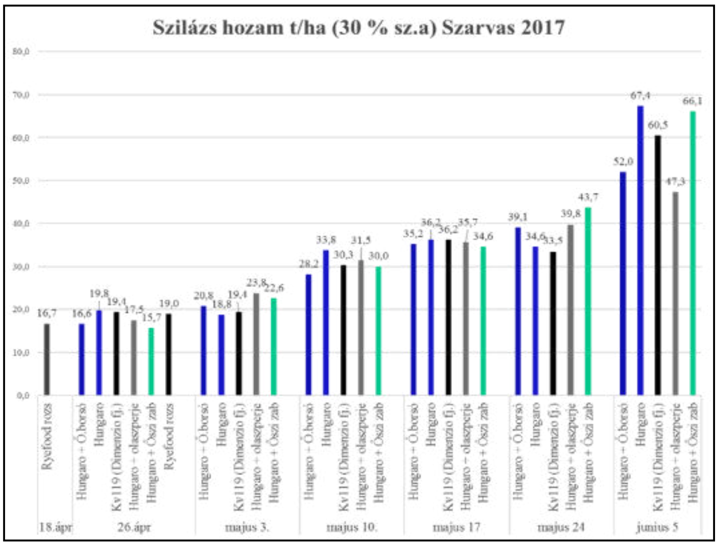
A tömegtakarmány kísérleteinkben elsősorban a 30%-os szárazanyagra átszámított szilázstömeget mértük, Szarvason és Iregszemcsén. A betakarított szilázs takarmányértékét is vizsgáltuk, azonban azt jelen dolgozatban a terjedelmi korlátok miatt nem tudjuk publikálni.

A kísérletben több vágási időpontot vizsgáltunk, ahol a hozamokon felül lehetőségünk volt a különböző időpontok minőségi eltéréseit is összehasonlítani.

A betakarítás első időpontja április 18-án történt, ahol még csak a Ryefood rozs volt betakarítható állapotban, 16,7 t/ha szilázsmennyiséggel *(4. ábra)*. A tritikálé fajta és keverékek még nem érték el a betakarítható állapotot.

A második kaszálás időpontjára (április 26.) már a tritikálé fajta és a keverékek is betakarítható állapotban voltak, így a rozs mellett mérhető szilázshozamokat kaptunk. A kísérletben látható, hogy a Hungaro és a Kv119 tritikálé fajtajelölt is teljesen versenyképes hozamokat adott a rozzsal szemben. Az elért szilázshozam 19,8 t/ha (Hungaro) és 19,4 t/ha (Kv119) volt a tritikálé tiszta vetésű parcelláiban a rozs 19,0 t/ha (Ryefood) eredményéhez képest.

A harmadik kaszálás idejére (május 3.) a rozs már nem szerepelt a kísérletben, mert azt az ismert technológia szerint már minőségileg nem megfelelő takarmányérték jellemezte. A tritikálé parcellák minőségi paraméterei alapján azonban még nem következett be minőségromlás, ezért az ott elért 18,8-23,8 t/ha szilázshozamok mindenképp részei a technológia kialakításának.



4. ábra Tritikálé és rozs tiszta és kevert vetés szilázshozamai Szarvas 2017.
Figure 4. Triticale and rye pure and mixed sowing grains of silage, Szarvas 2017.

A későbbi egy hetes betakarítások során a szilázshozamok fokozatosan nőttek (30,0-67,4 t/ha) szilázshozamig, azonban a számított 30%-os szárazanyagra számított mennyiség nem esett minden esetben egybe az optimális takarmányminőséggel, növekvő rosttartalom, csökkenő nyersfehérje tartalom jellemezte a szilázs minőségét.
A kísérletben látható volt, hogy a hozamok tekintetében a tritikálé fajta és fajtajelölt teljesen versenyképes a Ryefood fajta hozamaival, annak a hazai gabonaszilázs termesztésben jelentős szerepe lehet, ha az a takarmányminőség kritériumainak is megfelel.

Következtetések

Kísérleteinkben, illetve a hazai termesztési gyakorlat eredményeiben is megállapítható volt, hogy a tritikálé fajták alkalmasak gabonaszilázs termesztésére. Ebben a hazai nemesítésű fajták igen kedvező eredményekkel termeszthetők. A klasszikus gabonaszilázs növény a rozs terméseredményeivel hasonlítottuk össze a tritikálé fajták eredményeit.
Megállapítottuk, hogy a tritikálé még igen versenyképes hozamokat ad, akkor is, amikor a rozs már „elvénült” és annak minősége még megfelelő takarmányértéket, minőséget ad. Ezzel a betakarítás optimális ideje jelentősen kitolható, megnyújtható, amivel jobban biztosítható a megfelelő minőségű tömegtakarmány az állattenyésztő telepek igényeihez igazodva.
Fontos megállapításunk volt az is, hogy az új, hazai nemesítésű tritikálé fajták többcélú hasznosításában a szemtermés célú hasznosításán kívül kiemelkedő szereppel bírhat a tömegtakarmány célú hasznosítás, amellyel a kockázatos silókukorica termesztés részben kiváltható.

Összefoglalás

A hazai növénynemesítés kiváló hátteret ad a szárazságtűrő növények kialakításához. A vizsgált gabonafajták (Hungaro tritikálé, Ryefood rozs) kiválóan alkalmasak gabonaszilázs előállítására. A gabonafélék megtermelt szilázs mennyisége versenyképes a kukoricáéval, de nem annyira érzékenyek az aszályra. A klímaváltozás hatására a nyári félév csapadékmennyisége várhatóan csökkenni fog. A vizsgált gabonafajták a téli félév csapadékával nagy mennyiségű szilázs megtermelésére képesek. Megállapítottuk, hogy a tritikálé szilázs alkalmas a rozs szilázs kiváltására, illetve azzal együtt kiválóan termeszthető. A tritikálé kedvező tömegtakarmány minősége tovább fennmarad, mint a rozsé. A tritikálé szilázs hosszabb ideig ad kedvező minőséget, ezért a betakarítás jobban szervezhető, mint a rozs esetében. A tritikálé még április végén, május elején is kiváló takarmányt ad, amikor a rozst már betakarították.

Kulcsszavak: fajta, tritikálé, rozs, szilázs,

Köszönetnyilvánítás

A publikációt az EFOP-3.6.1-16-2016-0016 azonosítószámú, SZIE Szarvasi Campusának kutatási és képzési profiljának specializálása intelligens szakosodással: mezőgazdasági vízgazdálkodás, hidrokultúrás növénytermesztés, alternatív szántóföldi növénytermesztés, ehhez kapcsolódó precíziós gépkezelés fejlesztése című projekt támogatta.

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BIOLOGICAL BASIS OF TRITICLE PRODUCTION, POSITION FOR SEEDS AND VARIETIES

Abstract

National plant breeding provides an excellent background for the development of drought-tolerant plants. The examined cereal varieties (Hungaro triticale, Ryefood rye) are excellent for the production of silage. The amount of silage produced by cereals is competitive with maize, but not so sensitive to drought. As a result of climate change, the precipitation of the summer semester is expected to decrease. The cereal varieties examined can produce a large amount of silage with the precipitation of winter semester. It has been found that triticale silage is suitable for rye silage, and can be produced with it. The good quality of triticale forage continues to grow like rye. Triticale silage offers a favorable quality for a longer period of time, so harvesting can be better organized than in rye. Triticale still offers an excellent forage at the end of April and early May, when rye have been harvested.

Keywords: variety, triticale, rye, silage

VÍZGAZDÁLKODÁSI SZEKCIÓ

CLIENT SOFTWARE FOR DOWNLOADING AND ANALYSING EO DATA, IN PARTICULAR MONITORING INLAND EXCESS WATER AND ARIDITY

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Introduction

By launching Sentinel-2 B (the second member of a satellite pair) in March 2017 [1] the European Space Agency (ESA) provide freely accessible and usable Earth Observation (EO) data of higher spatial, spectral and temporal resolution then ever before. Sentinel satellites operate within the framework of Copernicus Programme [2] established by the ESA and the European Commission. The goal of the programme is that the European Union and all inhabitants of the world gain the most advantages from the opportunities offered by the space industry. Data collected by the Sentinel satellites and provided by Copernicus Programme offer outstanding chances for several different fields of science. When applied adequately, EO data represent an unmatched information source for learning about the state of our environment.

However, using this data set raises several important questions in connection with practical researches. University employees (SZIE) and students (SZIE and SZTE) actively using satellite remote sensing tools and interviewed at the planning phase of software development appointed data handling issues due to the size of data as well as geoprocessing problems related to data processing. According to them, these features makes analysis and research itself complicated and time consuming. In case of data management file sizes represent the main challenge, since it is in the gigabyte range even in case of the smallest downloadable ESA data packages. These data (satellite image) contains 16-bit integer values. In many occasions we have to work with floating point values (e.g. normalised difference indices, out of which NDVI is the most well-known and most widely used) and this conversion significantly increases the data size immediately. All operations implemented on the downloaded data by using GIS tools during the preparations of satellite images for analysis can be considered as geoprocessing operations. Coordinate transformations, different kinds of corrections, cloud masks, algebraic operations implemented on rasters (satellite image swaths), making cut-outs or format conversions. Many mistakes can be made during either data management or geoprocessing operations. These failures result false data and eventually lead to inaccurate or, in worse cases, incorrect conclusions. This can be avoided with adequate professional knowledge, although it still does not reduce the time- and resource-consuming nature of the above-mentioned operations.

Our objective is to design and develop a client software that makes it possible for researchers to skip these data management and preparational measures and to access directly to the necessary satellite data prepared for analysis. They do not have to handle huge files, but only those cut-outs displaying the geographically located research area delineated by the researchers.

An important aspect is to make the download of long time series data related to a given sample area possible by a single interaction of the user.

Another emphasised aim is to implement the functionality regarding both the monitoring activity of the selected areas and the visualisation of results, particularly in case of monitoring inland excess water and aridity in areas under agricultural production.

Two levels are distinguished in the functionality of the software:

Level 1 – anonymous data download and request of basic statistics by using polygons determined on-the-fly which are not stored.

Level 2 – full functionality subjected to user registration. Data download, statistical data and operation monitoring on polygons saved in the users' accounts.

Methods

Parameters of Sentinel-2 data

Parameters of data collected by the MSI sensor [4] found on board of the Sentinel-2 satellites [3] can be given by temporal, spatial, spectral and radiometric resolution.
Temporal resolution is determined by the orbits of satellites. In case of Sentinel-2 satellites this value is set by the return frequency –in what intervals do the satellites return to a given location above the Earth's surface. Both Sentinel-2 satellites have a return frequency of 10 days, therefore the duo, due to the 180 degree relative shift in orbit from each other, has 5 days return frequency. The temporal resolution of Sentinel-2 constellation is 5 days. In practice data are available even more frequently, because imaging swaths alongside the orbit of the satellites show increasing overlaps heading toward the polar circle. Thanks to this phenomenon 3 to 4 days of real temporal resolution can be achieved in the Carpathian Basin.
By spatial resolution we mean the surface representation of certain detectors found on board of the satellites. This value indicates the size of the area shown in one pixel of the digital images taken by the satellite equipment. In case of data collected by the methods of satellite remote sensing the units of measurement are usually cm, m or km. As for Sentinel-2, the available spatial resolutions are 10 m, 20 m and 60 m. Four bands have 10 m of spatial resolution, out of them three are in the visible spectrum, while the fourth is a wide near infrared (NIR) band (the central wavelength is indicated in brackets): blue (490 nm), green (560 nm), red (665 nm) and NIR (842 nm) (Figure X-a). These band support the record of high resolution real colour and infrared composite images as well as the creation of more accurate NDVI maps as regards of spatial resolution.
Three bands with 20 m resolution can be found in "red edge" range (705 nm, 740 nm and 783 nm), one band belongs to the NIR range (865 nm) and two bands to the short wave infrared (SWIR) range (1610 nm and 2190 nm). Red edge bands are generally narrow slices of the electromagnetic spectrum and are perfectly suitable for examining the ecophysiological parameters and dynamics of flora due to their place in the spectral space. The NIR band with 20 m resolution is considerably narrower than its 10 m counterpart

allowing, in spectral sense, the calculation of much more accurate NDVI values. SWIR bands generally make the examination of moisture content in vegetation by using atmospheric windows.
Three bands are available with 60 m spatial resolution (443 nm, 940 nm and 1375 nm). They are primarily used for the atmospheric correction of the other bands.
As far as spectral resolution is concerned 13 bands are available in Sentinel-2. They are surface reflectance intensities detected in various ranges of the electromagnetic spectrum. Radiometric resolution means the measurement scaling of detected reflectance intensities, i.e. which scale and which resolution is applied when the measured intensities are transformed into digital data. Radiometric resolution of the MSI sensor is 12 bits, thus 4096 different values can be set between 0 and 4095. However, images are published in 16-bit data, which means that 65536different pixel value exist in the range between 0 and 65535. It is a considerable improvement compared to the previously used Landsat (4 to 7) satellites in case of which data is in 8-bit format, thus 256 values exist between 0 and 255. It can clearly be seen that the radiometric resolution of Sentinel-2 can be considered as finely scaled.

Access to Sentinel-2 data

Data of satellites belonging to the Copernicus Programme are provided for download by ESA via the Copernicus Open Access Hub [5] platform. Manual download is implemented through Open Hub, while programmed download is made by using Api Hub. Data access service of ESA is currently available at so-called TILE and GRANULE level. TILE represents a 100 by 100 kilometres area; its average download size is around 800 MB. GRANULE represents a larger unit determined by the orbit of the satellites and covering the entire width of the scope. A GRANULE contains several TILEs and as such, its download size is approximately 6.5 GB. There is no possibility to access smaller amount of data (cut-outs), thus data collection and management has to be carried out at least in TILE level, even if the data analysis is implemented in parcel or sample area level. More efficient access to data can be facilitated by a data processing and data provision chain – a technology pipeline – built by 3rd party service providers and participants of the start-up scene supported by ESA. Currently the Amazon Web Service (AWS) [6; 7] offers effective service for cloud-based data storage onto which advanced applications and automated services can be built. T-Systems is working on the elaboration of similar services in Europe.

Data processing chain

As it was mentioned above, services provided by AWS can serve as fundaments for any kinds of advanced web services. The prerequisites of developing the software we have defined is to be able to collect web-based data at the level of cut-outs as well as to connect to an application which fulfils the data collection and processing functions and which, if necessary, provides operation monitoring services. In case all the above requirements are met, the client software with the functions described in its specifications can be developed.

Two start-ups of ESA-BIC (Business Incubation Centre) [9] operated by Science Park Graz (SPG) [8] propose a solution for the specific service of data collection and monitoring activities built on these collected data. Sinergise [10] excelling in web-based provision of Sentinel data offers satellite data found in the cloud-based storage spaces of AWS. Sinergise uses Web Map Service (WMS) and Web Coverage Service (WCS) protocols. Based on this service CropOM [11] has developed its Satellite Monitoring API that is a dedicated agricultural data collecting, operational monitoring and alert service able to support precision (variable proportion dispense) procedures by application maps. By connection established to Satellite Monitoring API developed by CropOM we can have direct access to necessary functions which include the results of the entire technology chain (ESA -> AWS ->Sinergise ->CropOM ->our software). Built on the service provided by CropOM the software we designed can be developed.

Software development solution

Our task is to create a user interface where all parameters needed for data download and analysis can be entered by the most simple and transparent way possible. Development of the client software is carried out on web-based solutions, thus the user interface is a browser application. Simple use regardless of the actual location and the cross-platform nature of the application also support this direction of development. Of course, a backend layer is also a part of the software. It can be considered during development, in particular for Level 2 where data of registered users including their set polygons shall be managed. Open-source and free-to-use components are involved during the development of the software. Javascript and Python programming languages are used in client and server sides, respectively. The following Javascript directories are engaged for running the client side application: jQuery, Bootstrap, OpenLayers, ChartJS. As for the server side, management of data is implemented by PostgreSQL database, while using PostGIS extension for handling geographical data (i.e. polygons). We establish communication with CropOM Satellite Monitoring API on the server side. We use cURL for this connection.

We make data download as well as the visualisation of basic statistics possible at Level 1 via the user interface of the software. As far as Level 2 is concerned, users –beyond all Level 1 functions – can set and save their sample areas, implement more complex assessments and use all services provided by CropOM (i.e. operation monitoring, alert function, creation of management zones and vector download of zonal files).

Results

At the time of writing this article the first phase of development (Level 1) has been completed. The software can be run locally and is still under development status. Version containing Level 1 is ready to launch. Place of publication (i.e. the server) is not yet determined, thus we cannot provide a URL for it.

In spite of the local function mode the software has already provided actual support for several researches and research groups working in St. István University during the data collection phase.

Based on first experience time needed for satellite data collection (from delineating the sample area until the access to data prepared for analysis) has decreased from 3 to 4 hours to approx. 6 minutes in case of data related to certain times. As for time series analysis the previous average of 10 to 20 hours has been reduced to around 15 minutes. These time frames were measured when dealing with sample areas of approx. 1000 hectares and presuming adequate GIS knowledge. Researches utilising satellite data are really diverse; different areas require different sets of data as input. Accordingly, time spent on preparing these data also covers a wide range. However, it shows considerable alterations only in the time needed for manual processing, while it does not have pivotal impact on the time of data preparation completed by using the software.

Summary

Most recent tools used in the downstream segment of the space industry provide possibilities for acquiring free and excellent resolution data. This advancement opens unmatched opportunities for agricultural and environmental researches.

We set the aim of creating a tool for researchers in which they can reach the essential data directly and quick, avoiding the problems emerging during data management and geoprocessing. It is also an objective to radically accelerate the process of data collection and preparation for analysis.

In order to achieve these goals we recommended the development of a web-based client software with a simple and transparent user interface that makes downloading the above-mentioned data and time series as well as displaying basic statistics possible. We also made suggestions as regards of enlarging the functionality of the software and storing user data together with the new possibilities opened by these improvements.

Beside the self-developed user interface we intended to utilise the technology chain built for handling satellite data enabling sophisticated data management in web-based environment. We used open-source and free-to-use components during the development of the software.

The completed software module (Level 1) allows to download time series data in a simple way as well as displaying basic statistics related to the selected areas, with particular attention paid on inland excess water and aridity.

Active researches use this software in St. István University considerably reducing the time spent on data collection and processing as well as avoiding problems connected to collecting and processing data.

The software is currently in pre-publishing phase; it can be run in local environment.

Acknowledgement and notes

We thank to the CropOM Team who have made the services of their enterprise available free of charge in order to develop our software. Furthermore, they offered a free-of-charge 5000 hectares annual subscription regarding the use of Satellite Monitoring API for research purposes.

The software development has been implemented and this publication is created in number EFOP-3.6.1-16-2016-00016 The specialise of the SZIU Campus of Szarvas research and training profile with intelligent specialization in the themes of water management, hydroculture, precision mechanical engineering, alternative crop production within the framework of EFOP-3.6.1-16-2016-00016 project.

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[9]http://www.esa.int/Our_Activities/Space_Engineering_Technology/Business_Incubation/ESA_Business_Incubation_Centres18
[10] https://sinergise.com/
[11] http://cropom.com/

CHANGES IN THE NUTRIENT CONTENT OF MAIZE DUE TO DIFFERENT WATER AND NUTRIENT SUPPLY

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Introduction

Information on nutrients in plant parts of maize is essential.On the one hand, it is important in terms of nutrition; on the other hand, nutrients in plant parts re-turned into soil affect the amount of fertilizer to be delivered.
The basic demand of sustainability is that the supplementation of water and nutrients should happen according to the actual demands. Special attention shall be paid on the maintenance of nitrogen balance. The amount of yield will be easier to plan by irrigation, consequently the nutrient requirement can be calculated more exactly than without irrigation.
In this paper the amount and nutrient concentration of the different plant organs as well as the conclusions derived from these data are discussed.

1. Literature overview

The fertiliser dose above a certain level is serving not the satisfaction of plant requirement, but the charging up of the soil (*Sarkadi 1991, Füleki and Debreczeni 1991).*Following the saturation of the soil it is not only excess, but also has environment pollutant effect. However, the deficient nutrient supply results the decrease of soil productivity.
In the judgement of the specific nutrient requirement of plants there is a big uncertainty and arbitrariness which can be due to the fact that both the amount of nutrients taken up by plants and the total nutrient content per grain yield are fluctuate among wide limits. It was found by *Kádár* (1992) – citing 22 foreign and 12 home sources – that for 1 t/ha total grain yield of maize nutrient amount vary between the following values: 20 to 43 kg/t nitrogen, 7 to 16 kg/t phosphorous and 21 to 51 kg/t potassium.

From this data it can partly be concluded that the plants' nutrient content expresses not necessarily their demand but rather shows the effect of circumstances; on the other hand, these limits of values are too large to be able to choose the adequate amount.

According to the present methods of the fertiliser expert advisement the plants nutrient requirement is taken into consideration as the multiplication of specific nutrient content and the yield. However this would be real only in that case, if neither the harvest index nor the nutrient content of plant organs would not modified with the varying yield.
The harvest index of maize increases with increasing fertilizer doses, depending on the year *(Micskei 2011, Bruns-Ebelhar 2006, Berzsenyi 1993).*
It was stated be several researchers concerning the variability of nutrient content of plant organs, that it is in a positive correlation with the nutrient supply and the nutrient content of the soil (*Bruns and Ebelhar 2006, Bergmann and Neubert 1976, Győri 1988).* And the

examinations related to water supply (precipitation and irrigation) proves, that theirs increase reduces the nutrient content of plants also in case of favourable nutrient supply (*Debreczeni 1987, Ruzsányi 1992, Lásztity and Csathó, 1994).*

Materials and methods

The experiments have been carried out in Szarvas, Hungary, in the Lysimeter Station of the Research Institute, on field plots and in lysimeters. The size of plots was 4 x 8 m (32 m^2), and of lysimeters 1 x 1 x 1 m (1 m^3), which were placed in the middle of plots.
The two-factor long-term experiment was set up with 4 repetitions, split-plot layout:
The *water supply* treatments were the following:
a_1 - non-irrigated *control* (natural rainfall)**;** a_2- irrigated with *one third* of optimum water supply; a_3 - irrigated with *two thirds* of optimum water supply; a_4 -*optimum* water supply (irrigated according to the demand of plants).
In the treatment a4, the disposable moisture content of the soil was kept above 50% saturation level in the active root zone. Water supply was carried out by dripping pipelines.
Within the main treatment (water supply) the *nutrient levels* were:
b1, b2, b3, b4 = 100, 200, 300, 400 kg/ha NPK substances in ratio 2:1:1.
The marking of treatments happens by two numbers. The first number means the water supply-, the second the nutrient supply treatments (e.g. 11 = a1b1).
For the examination of yield components all of the plants were prepared in lysimeters.
The type of the soil is chernozem meadow, which is well supplied with phosphorus and potassium, and has medium nitrogen content, 2,5-3 % humus, and 50 % clay. Its natural water capacity is 40 volume percent, half of which is disposable water.

Results and discussion

In this paper the organic matter production of maize and the ratio of plant organs and their nutrient content is examined by using 20 years long experimental data.
In *Table 1* average values of 20 years (1978 to 2001) regarding 16 treatment combinations of 4 water and 4 nutrient supply are demonstrated regarding the total organic production of maize and the components. It can be seen that the change of the grain yield is much bigger than that of the other plant organs. The two factors together increased the dry grain yield of maize in lysimeters by three times more compared to the basic (non-irrigated, 100 kg/ha NPK) treatment, in average of 20 years.
Treatments, however, modify the amount of by-products much less than grain yields. Corn grain grows in all dry matter with increased water and nutrient supply (Table 1), i.e. harvest-index grows.

2. *Table 1:* Dry matter yield of maize plant organs (t/ha) in average of 20 years

Dry yield in lysimeters (t/ha)											
Treatments	Grain	Stalk	Leaf	Cob	Total	Treatments	Grain	Stalk	Leaf	Cob	Total
11	3.1	3.5	2.5	0.7	**9.8**	**31**	5.4	3.9	2.8	0.9	**13.0**
12	3.5	3.6	2.6	0.8	**10.4**	**32**	7.1	4.1	3.0	1.1	**15.3**
13	3.6	3.6	2.6	0.8	**10.6**	**33**	8.7	4.4	3.3	1.2	**17.5**
14	3.4	3.6	2.6	0.7	**10.3**	**34**	8.9	4.4	3.3	1.2	**17.8**
Mean	**3.4**	**3.6**	**2.6**	**0.7**	**10.3**	**Mean**	**7.5**	**4.2**	**3.1**	**1.1**	**15.9**
21	4.7	3.8	2.7	0.9	**12.1**	**41**	6.3	4.0	2.9	1.0	**14.3**
22	5.5	3.9	2.8	0.9	**13.1**	**42**	7.8	4.2	3.1	1.1	**16.3**
23	6.0	4.0	2.9	1.0	**13.8**	**43**	9.5	4.5	3.4	1.3	**18.7**
24	6.0	4.0	2.9	1.0	**13.8**	**44**	10.1	4.6	3.5	1.3	**19.5**
Mean	**5.5**	**3.9**	**2.8**	**0.9**	**13.2**	**Mean**	**8.4**	**4.3**	**3.2**	**1.2**	**17.2**

3. The NPK content of different plant organs of maize:

Not only the quantity and ratio of plant organs, but also theirs NPK content were modified significantly by water- and nutrient supply.

In *Table 2* the NPK content of different plant organs of maize in percent of dry matter is indicated.

4. *Table 2:* NPK contents of maize yield components in the lysimeter experiments in the average of 20 years

Treatment	N%				P_2O_5 %				K_2O %			
	Grain	Stem	Leaf	Cob	Grain	Stem	Leaf	Cob	Grain	Stem	Leaf	Cob
11	1.44	0.37	0.68	0.45	0.76	0.38	0.36	0.22	0.50	2.44	0.82	1.06
12	1.56	0.46	0.97	0.56	0.77	0.34	0.42	0.26	0.51	2.58	0.99	1.26
13	1.67	0.55	1.06	0.69	0.78	0.33	0.43	0.29	0.51	2.91	1.04	1.25
14	1.74	0.67	1.16	0.73	0.79	0.32	0.50	0.38	0.52	3.14	1.34	1.31
Mean	**1.60**	**0.51**	**0.97**	**0.61**	**0.78**	**0.34**	**0.43**	**0.31**	**0.51**	**2.77**	**1.05**	**1.22**
21	1.36	0.33	0.56	0.40	0.78	0.40	0.27	0.19	0.50	1.92	0.83	0.92
22	1.48	0.38	0.64	0.43	0.76	0.38	0.32	0.20	0.49	2.34	0.94	0.93
23	1.65	0.45	0.79	0.49	0.77	0.28	0.34	0.24	0.47	2.66	0.97	0.97
24	1.70	0.54	0.90	0.55	0.76	0.28	0.37	0.27	0.47	2.67	1.03	1.10
Mean	**1.55**	**0.43**	**0.72**	**0.49**	**0.77**	**0.35**	**0.33**	**0.23**	**0.48**	**2.50**	**0.94**	**0.98**
31	1.23	0.29	0.59	0.32	0.75	0.41	0.33	0.16	0.47	1.83	0.78	0.64
32	1.35	0.33	0.66	0.36	0.76	0.39	0.35	0.18	0.45	2.25	0.81	0.70
33	1.45	0.40	0.73	0.42	0.73	0.35	0.36	0.24	0.45	2.44	0.95	0.73
34	1.56	0.50	0.76	0.46	0.74	0.31	0.37	0.25	0.43	2.87	0.98	0.80
Mean	**1.40**	**0.38**	**0.68**	**0.39**	**0.75**	**0.36**	**0.35**	**0.22**	**0.45**	**2.35**	**0.88**	**0.72**
41	1.19	0.29	0.49	0.32	0.74	0.44	0.34	0.13	0.47	1.85	0.89	0.70
42	1.27	0.32	0.58	0.34	0.75	0.40	0.35	0.17	0.46	1.92	0.86	0.83
43	1.40	0.38	0.66	0.38	0.75	0.36	0.35	0.19	0.45	2.05	0.94	0.87
44	1.51	0.47	0.75	0.44	0.76	0.35	0.35	0.23	0.44	2.31	1.00	1.36
Mean	**1.34**	**0.37**	**0.62**	**0.37**	**0.75**	**0.39**	**0.35**	**0.20**	**0.45**	**2.03**	**0.92**	**0.94**

It was concluded regarding the change of nitrogen content in the plant organs that at same water supply the N % is increasing in every plant organ together with the higher dose of fertiliser.Increasing water supply lead to the decrease of nitrogen concentration provided that the nutrient supply remains the same.
The N % in the grain of maize at well water supply is lowest also in the case of good nutrient supply compared to the same nutrient supplied but not irrigated maize. Namely at the non-irrigated one the nitrogen concentration in plant is increasing by the effect of excess nutrient, if the yield is not enhanced as well. However, in that case if the good nutrient supply is combined with favourable water supply, the N % of plant is not increasing, because of there is no nutrient surplus, the highest yield it is needed more nutrient.

The phosphorous and potassium content of plant organs was not, or only slightly influenced by fertilisation. The reason of this can be the very high phosphorous and potassium content of the soil (over 700 to 900 ppm P and K content, respectively) which insured abundant supply of these nutrient elements.The change in Ca, Mg, Na and crude fibre content did not show correlation with irrigation treatments and NPK doses *(Table 3).*

*Table 3: C*orn content of Ca, Mg, Na and Crude in the water and nutrient supply treatments (expressed as a percentage of dry matter)

	dry grain yield				by-product		
treatment	crude fibre	Ca	Mg	Na	Ca	Mg	Na
	%				%		
a1b1	3.79	0.009	0.101	0.034	0.258	0.077	0.036
a1b2	3.56	0.010	0.098	0.024	0.199	0.068	0.044
a1b3	3.43	0.009	0.103	0.029	0.184	0.087	0.065
a1b4	3.56	0.010	0.101	0.041	0.238	0.089	0.051
mean	**3.59**	**0.010**	**0.101**	**0.032**	**0.220**	**0.080**	**0.049**
a2b1	3.51	0.015	0.092	0.031	0.201	0.070	0.033
a2b2	3.55	0.010	0.089	0.035	0.302	0.182	0.044
a2b3	3.45	0.007	0.108	0.032	0.233	0.072	0.037
a2b4	3.56	0.009	0.102	0.033	0.279	0.108	0.038
mean	**3.52**	**0.010**	**0.098**	**0.033**	**0.254**	**0.108**	**0.038**
a3b1	4.13	0.009	0.094	0.041	0.162	0.105	0.045
a3b2	3.62	0.030	0.096	0.046	0.202	0.075	0.046
a3b3	3.48	0.010	0.104	0.033	0.201	0.082	0.089
a3b4	3.70	0.011	0.109	0.023	0.218	0.096	0.037
mean	**3.73**	**0.015**	**0.101**	**0.036**	**0.196**	**0.090**	**0.054**
a4b1	4.17	0.011	0.092	0.029	0.171	0.080	0.050
a4b2	3.59	0.010	0.095	0.026	0.178	0.069	0.038
a4b3	3.73	0.010	0.104	0.032	0.246	0.094	0.049
a4b4	3.48	0.009	0.106	0.034	0.224	0.084	0.045
mean	**3.74**	**0.010**	**0.099**	**0.030**	**0.205**	**0.082**	**0.046**

The amount of nutrients taken up:

The quantity of nutrients taken up is determined primarily by the produced dry matter content and their nutrient concentration.The tendency regarding the amount of nutrients is very similar to that of the dry matter content. The majority of the absorbed N (58 to 75%), and phosphorous (50 to 71%) can be found in the grain. At the same time only 12 to 24% of taken up potassium can be detected in the grain, the remaining are in the vegetative mass, mainly in the stem (*Table 4)*.
It can also be seen from these data, that the fertilizer needs are influenced significantly by the fortune of secondary products, especially in case of potassium.
From the above-mentioned data the conclusion can be drawn that the amount of nutrients per grain unit would also decrease significantly with the increasing yield – due to the increase of harvest index – even if the nutrient concentration would be unvarying.In my opinion the actual nutrient content of plants expresses the nutrient requirement only in those cases when the nutrient supply is in line with the other factors.

Table 4: Distribution of the K absorbed by maize in different plant organs in the lysimeter experiment in average of 20 years

K_2O (kg/ha) a lysimeters											
Treat-ments	Grain	Stem	Leaf	Cob	Total	Treat-ments	Grain	Stem	Leaf	Cob	Total
11	15	85	21	8	**129**	**31**	25	71	22	6	**124**
12	18	92	25	9	**145**	**32**	32	93	25	7	**157**
13	19	104	27	10	**159**	**33**	39	107	31	9	**185**
14	18	112	34	10	**173**	**34**	39	127	32	10	**207**
mean	**17**	**98**	**27**	**9**	**151**	**mean**	**34**	**99**	**27**	**8**	**168**
21	24	72	23	8	**127**	**41**	29	74	26	7	**137**
22	27	91	27	9	**153**	**42**	36	81	27	9	**154**
23	28	105	28	9	**171**	**43**	43	93	32	11	**178**
24	28	106	30	11	**174**	**44**	44	106	35	18	**203**
mean	**27**	**97**	**27**	**9**	**160**	**mean**	**38**	**88**	**30**	**11**	**167**

Relations of average yields, taken up nutrients and nutrient requirement

The relation-examinations were implemented by using all data, but the results were strongly deformed by the asymmetric treatments (lot of nutrient paired with little water as well as the other way around).
Because of this fact correlation tests and the *figures* were drawn on the basis of 20 years average data of grains and their nutrient content by using the harmonised treatments only (11 to 12, 22 to 23, 33 to 34, 43 to 44).These figures show the amount of NPK found in the grains and in the whole plant as grains grew. Since these data originated from harmonized nutrition and water supply treatments, they could also be accepted as nutrient requirement values.

Parallel to the development of grains the total NPK content of maize is increased in a close linear or logarithmic way, but its extent is in every case smaller than that of the grains.Because of this the specific nutrient content decreases remarkably, especially for potassium (*Figures 1 and 2).*

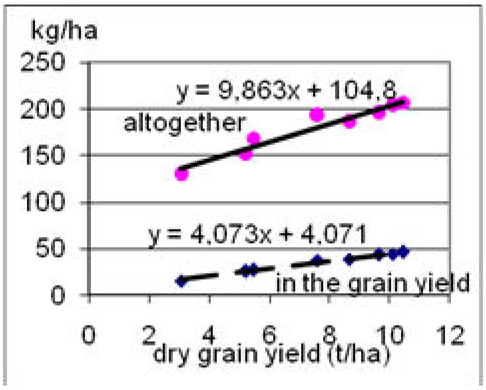

Figure 1: The K_2O content of maize in the function of yield

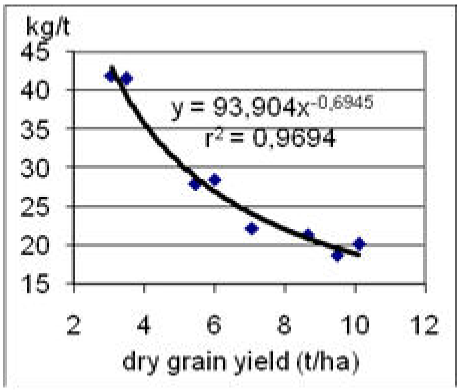

Figure 2: The specific K_2O content of maize

On the basis of the results the following similar equations are recommended for calculating the nutrient amount in grains as well as in the total dry matter of maize:

nutrient content in the grain (kg/ha)	*nutrient content in the total plant (kg/ha)*
N = 15X-3	N = 18X + 19
P_2O_5 = 7X+2	P_2O_5 = 8X + 23
K_2O = 4X+4	K_2O = 10X + 105

where x = the amount of the dry grain yield (t/ha).

A big part of nutrients–in case of potassium it can reach 75 to 85%– can be found in the by-products of plants.Nutrient balance and the amount of nutrients to be replenished depends significantly on the utilisation of these plant materials.

5. Conclusions

In this paper the amount of the different plant organs of maize, their NPK concentration as well as Ca, Mg, Na and crude fibre contents are introduced.
The main results and conclusions are the following:

- Water and nutrient supply increase the yield and the productivity until reaching the optimum level by positive interactions.
- The amount of stem and leaf is increased to a smaller extent than that of the grains by the effect of water and nutrient supply, thus the harvest index increases.
- Growing yield results the decrease of nitrogen concentration in the entire plant.

- Because of the decrease of N% and increase of harvest index the amount of nitrogen absorbed by the plant as well as the nitrogen requirement of the plant rise in a smaller extent than the grain.
- The majority of K can be found in the stem and leaf. Consequently, the potassium taken up by plants and the K-requirement increase to an even smaller scale with the increasing yield than in the case of nitrogen.
- P-concentration of maize does not considerably alter together with the increasing yield, but because of the rising harvest index the specific phosphorous content and P-requirement decreases with the growing yield.
- The Ca, Mg, Na and crude fibre content did not show any correlation with irrigation and NPK doses.

6. *Abstract*

The effect of water and nutrient supplies and their interactions is evaluated on the basis of 20 years of maize data. The experiments were carried out on field plots and in lysimeters built in the middle of plots in 4 by 4 treatment-combinations applying 4 repetitions.

In this paper the amount of the different plant organs of maize, their NPK concentration as well as Ca, Mg, Na and crude fibre contents are introduced.

It was found that the grain yield was increased only slightly by the separate effect of the two examined factors, while it was enhanced two or three-fold by their effect together, though the quantity of other plant organs rose by 20 to 30 % *(Table 1).* With the increasing grain yield the harvest-index also increased.

As the result of raising the fertiliser dose the N % was increased in all the plant organs and decreased by the irrigation. The K % was influenced only in the stem and leaf, while the P, Ca, Mg and Na content was influenced neither by the nutrient nor the water supply.

The amount of taken-up nitrogen can mainly be found in the grains of maize. A large part of phosphorus is also stored in the grain, whilethe majority of K content is situated in the stem and leaf.

Based on the results of the above-mentioned experiments it can be said that the total amount of NPK per one unit of grains(kg/t) is decreased significantly with the increasing yield, especially the quantity of potassium is involved *(Figure 1 and 2).* It means that the nutrient requirement necessary for reaching higher yields is increasing to a lesser extent than the yield. On the basis of the experimental results simple linear functions are offered in order to establish the nutrient requirement of maize.

Keywords:

water supply, nutrient supply, maize, nutrient content

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HIDROKULTÚRÁS TERMESZTÉS SZEKCIÓ

Development of a calculation model for assessing specific nutrient and water management indicators of hydroponic technologies

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Introduction

Hydroponics is the most intensive form of plant forcing. The environmental factors are controlled at technology level, while the goal is to achieve the highest possible yield. Getting rid of the soil also serves the purposes of advanced control, since the complex physical, chemical and microbiological systems of the soil can indirectly influence the functioning of roots and thus the yield as well. On the contrary, hydroponics no or only in minimal extent modify the conditions of moisture and nutrients. Their primary aim is to hold the root systems and provide aeration to the root zone. In some casesdifferent level of buffering, nutrient and water absorbing capacity can also be observed.

Literature review

The intensive technology is paired with outstanding water and nutrient demand that is supplemented by programmed irrigation as well as growing solutions of determined quality and quantity. Applied technologies vary significantly as regards of managing drain water. In case the surplus water (drain water) leaves the facility we talk about open technology. It has greater ecological consequences; the nutrient content of the drain water is a loss that induces impacts on the environment and water in particular. It also influences economic efficiency. In closed systems recycling is applied that reduces the amount of nutrients reaching the environment. It makes production more economical, but, at the same time, increases plant protection risks. In Hungary hydroponics are usually function as open systems: the surplus drain water leaves the structure. That is why it is important how much water and nutrients are used for creating a product unit. Literature mentions 30 to 60% of nutrient loss in open systems (Siddigi-Glass, 1981), while closed production may lead to 20 to 30% of water saving and 20 to 50% of nutrient reduction compared to closed systems – as literature describes (Voogt-Sonneveld, 1996; Tüzel et al., 2001).One key direction of technology development is to reducethe losses regarding open systems, improve the utilisation of water and nutrients while avoiding the plant protection risks of closed production systems (Grewal et al, 2010).

When assessing hydroponicsthe way of measuring the utilisation of water and different nutrients is still an unsolved question.

A simplified methodology published as an antecedent research (Rácz, 2007) adapts the nutrient utilisation % applied in arable crop production to hydroponics. It intends to determine such indicators that are suitable for measuring the impacts of water and nutrients in the product. Since then it has also become obvious that the quantification of environmental effects is more and more important. Such indicators should be developed that makes it possible to compare the amount of water and nutrients in different facilities, technologies, varieties, treatments etc. A well-established methodology would help to

decide whether a given intervention was successful in saving water and/or nutrients and, as such, reducing losses and environmental impacts.
In this study a new evaluation system is outlined and compared to the previously published data (Rácz, 2007). After the conclusions are drawn, this methodology can be assessed and developed.

Material and methods

The crops of tomato (*Solanum lycopersicum* L.) involved in the experiment can be found in Szarvas, in the Galambos educational facility of St. István University. A greenhouse built in 2016with almost 2,000 m^2gross and 1,800 m^2 net area and 6 m height was used for the research. Tomato seedlings (Aruba variety) were planted in 16 February 2017on once used coco peat growing medium. Crop density was 3.6 plants/m^2. The growing solutionwas dispensed by a Priva automatic equipment via two automatic irrigation valves. EC and pH control have been carried out under double-checked automatic actuation. This solution has been mixed in the 500 l tanks of stock solutions A and B. The irrigation machine administered these solutions using 100-fold dilution. Irrigation data and information on the yield were constantly recorded. The growing media were soaked one day prior to planting. Later in the vegetational cyclegrowing solutions made by four different recipes were applied.

Growing solution, mg/l	Fill-in	Blooming of 1st to 3rd vines	Blooming of 5th to 10th vines	Blooming of 12th vines	Until the end of the cultivation
N	353	376.7	306.2	265	249.7
P	76.5	47.2	49.4	49.4	26.7
K	361.2	529.7	488	342.8	353.3
Ca	322	242	181	194	216
Mg	75.2	66.2	52.2	48	59.2
S	138	109	94.2	98.1	103
Date:	02.16.	02.17.-04.23.	04.24.-07.31.	08.01.-10.07.	10.08.-12.15.

Table 1 Main components of the nutrient solutions used during the growing season, 2017

Total water and nutrient dispensing can be calculated based on the daily quantity of growing solutions and their nutrient content. The harvested yield was also measured. All data that are indicated and assessed here refer to 1 m^2. We intend to compare the results of Galambos research facility with the numbers recorded for three different greenhouses in 2007.

Greenhouse Nr.	Yield kg/m²	Nutrients used g/m²				
		N	P	K	Ca	Mg
I.	42,5	226,0	54,8	358,2	162,6	42,8
II.	39,2	299,7	79,4	545,3	165,7	68,7
III.	22,5	224,9	75,5	408,0	136,0	65,1

*Table 2*Yields and nutrient demand in tomato hydroponic cultivation (rockwool) in 3 different greenhouses, Rácz (2007)

Results and assessment

Amounts of cumulated yields, growing solutions and nutrients have been calculated. Aggregated values were set by using the daily data so that this function-like visualisation makes it possible to read the parameter in question at each selected value.

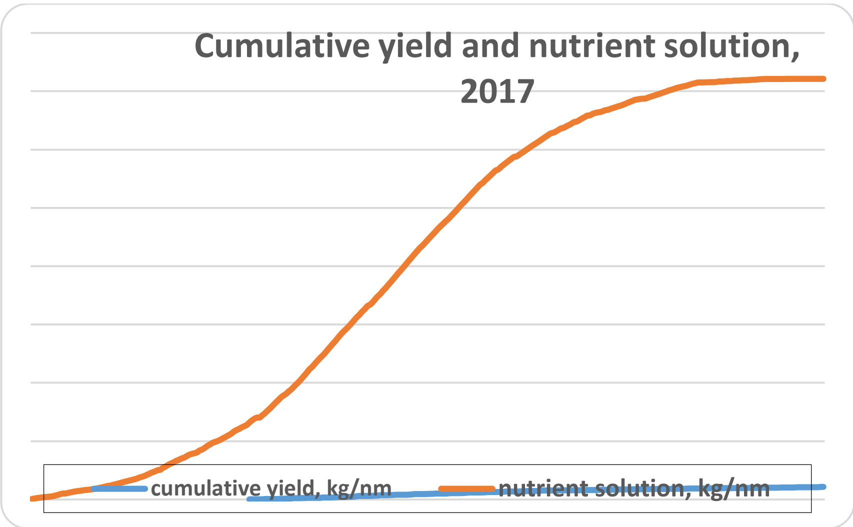

Figure 1 Yield of tomato and amount of the nutrient solution during the cultivation

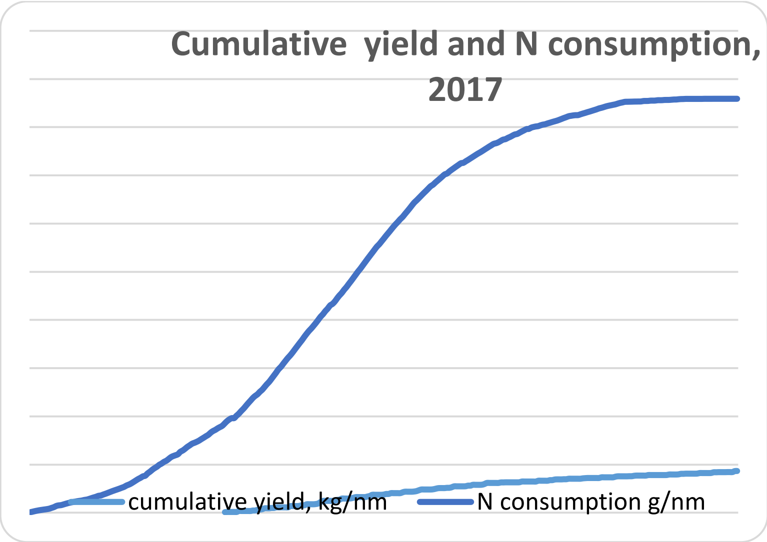

Figure2. Yield of tomato and nitrogen consumption during the cultivation period

We presume that this method ensures considerably higher flexibility for comparing the results of different greenhouses and other facilities than simply giving one ratio at the end of production using only the total yield and the total nutrient use.

Greenhouse	**Yield kg/m²**	**Growing solution l/m²**	**Nutrients used g/m²**				
			N	P	K	Ca	Mg
Galambos	43.35	1443.19	429.6	69.4	649.2	278.9	75.1

Table 3 Yields and nutrient demands in tomato hydroponic cultivation in Galambos greenhouse, 2017

With the help of concluding functions values connected to the yield data of 2007 can be read, and thus the comparison can take place.

Greenhouse	**Yield kg/m²**	**Nutrients used g/m²**				
		N	P	K	Ca	Mg
I.	42.5	429.6	69.4	649.2	278.9	75.1
II.	39.2	428.4	69.3	647.5	277.9	74.9
III.	22.5	324.2	50.1	500.0	195.5	54.1

Table 4 Nutrient requirements for different yield levels at Galamos greenhouse, 2017

Data indicated in Table 3 and 4 reveal that the cultivation technology of Galambos greenhouse required much more water and nutrients compared to that amount used in the previous experiment (Table 2).

Conclusions

The summarised data allow us to read the used amount of nutrients in relation with any yields during the whole production period. By having this information it is possible to compare it with the nutrient and water use data of other facilities. However, this method is suitable for assessing the utilisation of nutrients and water only in a limited way. Great differences in yields can represent the main risk: it is not at all the same if a stand can produce 22 kg/m^2 fruits or 22 kg has been harvested from it so far and further yields are expected. Another problem can be – based on the experience gained in Galambos – that remarkable alterations can occur among different growing media. Small binding capacity of mineral wool might modify the utilisation of nutrients in lesser extent than, for example, coco peat.

However, aggregated functions can be suitable for comparing water and nutrient use when similar yields and growing media are involved.

The development of methodology requires further research, but as a conclusion it can be said that all kinds of interventions (management, innovation, technology improvement) lead to the better utilisation of nutrients and water if they result higher yields without increased consumption of growing solution. It means that constant technology researches and developments are necessary in case of open production systems as well in order to reduce the environmental impacts.

Summary

Hydroponics is a super-intensive form of plant production. The environmental factors are controlled at technology level, while the goal is to achieve the highest possible yield.The intensive technology is paired with outstanding water and nutrient demand that is supplemented by programmed irrigation as well as growing solutions of determined quality and quantity.Applied technologies vary significantly as regards of managing drain water. In case the surplus water (drain water) leaves the facility we talk about open technology.It has greater ecological consequences; the nutrient content of the drain water is a loss that induces impacts on the environment and water in particular. It also influences economic efficiency.

According to literature several technological factors influence and control the utilisation of nutrients and water. It is difficult to compare the specific indicators of different facilities, because the amount of yield also has an impact on these indicators. The authors introduce a calculation method which provides possibility for comparison and assessment even if the yields are not the same.

Keywords:hydroponics, tomato, open system, efficiency of water and nutrient uptake, environment

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This publication has been completed within the framework of project no. EFOP-3.6.1-16-2016-00016 focusing on training and research profiles with intelligent specializations on the Szarvas Campus of St Istvan University involving agricultural water management, hydroponic plant systems, alternative crop production related to improving precision machinery in agriculture.

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Development of a calculation model for assessing specific nutrient and water management indicators of hydroponic technologies

Abstract
Hydroponic cultivation is a super intensive technology and the regulation of environmental factors at the technological level ensures that the highest yield is the production goal. Intensive technology is coupled with intense water and nutrient demand, which is replaced by regular irrigation, targeted amount and quality nutrient solution. Hydroponic technologies differ significantly in the treatment of excess water (drainage systems). If the overflow (drain water) leaves the greenhouse, we are talking about open technology, which has a greater ecological effect, the nutrient content of drain water is a loss, which not only impacts the environment, also affects economic efficiency.
According to the literature, the utilization of nutrients and water is regulated by several technological factors. The specific indicators for each greenhouse technologies are difficult to compare, because the amount of yield also affects these specific indicators. The authors present a computational model that allows comparisons and evaluations for different hydroponic technologies and different yields.

Keywords: hydroponic cultivation, tomato, open system, water and nutrient uptake efficiency, environment

PRELIMINARY EXPERIMENT ON WATER DEFICIT FOR UTILISATION OF HYDROPONICS WASTE MATERIALS

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Introduction

Stone wool applied asa growing medium in plant forcing is currently considered as waste material in Hungary. Its excellent water retention capacity as well as the accumulated nutrients and plant residues can have soil improving and yield increasing effects in certain areas of poorer soil quality. Notable amount of organic matter, different micro- and macronutrients remain in stone wool after removing the forced plants. In case the mineral wool contains neither heavy metals nor other environmentally harmful substances, it can be utilised in agricultural production. Global climate change challenges arable crop production in an increasing manner. Weather extremities become more and more frequent. One of the biggest facilities processing industrial tomato is situated in Kecskemét. The area of Danube-Tisza Interfluve is prone to aridity. The majority of soils around Kecskemét have poor water management characteristics, so growing industrial-scale tomato without irrigation is turning to be uneconomic.The objective of our experiment is to determine how the incorporation of mineral wool originated from hydroponics impacts the yield and main industrial processing parameters of tomato grown in the sandy soils of Kecskemét. We want to collect valid information so that we can set up an experiment regarding the use of hydroponic waste materials. We would also like to examine the impacts of stone wool waste on the value measures of outdoor industrial tomato production.

Literature review

Both the production and consumption of tomato, either fresh or processed, show a constantly increasing trend worldwide. Average Hungarian production was 174,000 tons regarding the above-mentioned four years. It represents approximately 0.8% of the total European yield (FAOSTAT, 2015; Helyes 2015). New investments in processing industry prospect the increase of the amount of tomato produced in Hungary. Large amount of raw material with outstanding nutrient content is needed for domestic processing in order to create high quality tomato products. They can also be suitable for improving average quality concentrates (Helyes, 2015). In case of countries with relatively arid climate optimal for outdoor tomato growing average yield can be expected around 100 to 130 t/ha. According to Hungarian data the 100 t/ha production is achievable with the use of intensive field production technology and several highly productive tomato hybrids (Helyes, 2013.)

Several factors influence dry matter content, such as variety, ripeness of the berry, nutrient and water supply of the plants (Mahakun et al, 1979) as well as other

environmental parameters (Helyes et al. 2008b). Yield of a unit area is determined by the size and number of berries grown in a plant. It is inversely proportional with dry matter content (Lapushner et al., 1990; Helyes et al., 2008a; Pék et al., 2014). Brix° is used for indicating soluble dry matter content; its value usually varies between 4 and 6.5 and is influenced by numerous factors (Varga 1983; Varga 1988; Cselőtei 1988, Helyes 1999). Large part of soluble dry matter content (Brix°) consists of reducing sugars: this value is between 50 and 70% according to Davis and Hobson (1981) and Helyes (1999), while Helyes et al. (2008b) set this value at 60 to 70%.
Development type, berry size and the number of set fruits fundamentally determine the productivity of tomatoes, although the method of production and the technology applied play important roles, too (Ho, 2003). According to the research of Macua et al. (2003) the amount of irrigation water significantly influences the living conditions of plants. Cahn (2003) et al. claim that the more water a plant receives during the phase of crop formation, the lower the Brix° will be. The weather of last weeks before harvesting considerably influences harmonised ripening and dry matter content of industrial tomato varieties. Larger rains can remarkably deteriorate the Brix value. In some years the acceleration of ripening is unavoidable (Helyes et al, 2006) one way of which can be the ceasing of irrigation (Helyes et al, 2008a). Water withdrawal in the last 3 to 4 weeks before harvesting (cut-off method) has not provided unambiguous results in Hungarian experiments, thus water deficit irrigation might be the solution for ensuring adequate Brix value without suffering considerable yield loss (Johnstone et al, 2005). We could not find any literature references regarding successful water deficit treatments on sandy soils.

Material and methods

The plant stand representing the subject of the examinations was planted in Kecskemét, using the experimental field ofthe National Agricultural Research and Innovation Centre Vegetable Crop Research Department. The tomatoes were put in loose sandy soil (K_A: 31) in 2016. Following the soil analysis a nutrient supplementing plan has been elaborated by taking the specific nutrient demands of industrial tomato into account. In case of 80 t/ha yield the active substance requirements are as follows: 280 kg N; 120 kg P and 352 kg K. Complex granulated NPK fertiliser (15-15-15) and granulated poultry manure (Orgevit) was dispensed during the spring machine spading. Seedlings were grown in heated greenhouse using KITE trays. During the five-week-long seedling production phase Ferticare (24-8-16) growing solution has been applied. The tomatoes were planted in 18 and 19 May. Unorosso F1 variety has been used in the experiment. Each parcel contained 51 plants in four repetitions. Ferticare (15-30-15) starter fertiliser was used to promote root development at the time of planting. Planting and row distance were 22 cm and 130 cm, respectively. The space between two rows was covered by 120 cm wide geotextile in order to prevent weed growth. A tensiometer was put into each band of the experiment to determine the time of irrigation with sufficient accuracy. Two-metre-widespacings were left between the bands to avoid the mingling of the treatments and their effects. The uniform water and nutrient supply was ceased five weeks prior to the planned date of the harvest. Tomatoes had adequate leaf area by then, flowering has been finished, fruits were developed. The first berries were about to reach their final size. After this turning point plants were irrigated using three different amounts (100%; 75% and

50%) of water, together with two levels of potassium. The fourth parcel was the non-irrigated control group. Based on the data received from the tensiometers and the guidelines of Helyes and Varga (1994) water demand of the plants has been determined in mm as one-fifth of the daily mean temperature.Regarding the amount of K calculated by the specific nutrient demand of the plant the remaining dose was administered in one parcel and cancelled in the other. Harvest was carried out in three different dates. Since the 51 tomatoes were planted in three rows (17 plants/row) in each parcel, they were harvested in one-week intervals in order to determine the pace of ripening. Machine harvest was imitated: plants were cut, all the berries shaken off and classified under four categories (ripe, burgeoned, green and unhealthy/cull). Fruits were also counted and weighted.Red and orange, evenly coloured fruits fell into the ripe category. A berry was considered burgeoned if it contained orange and green patches in varying proportions. Uniformly coloured green tomatoes belonged to the green category. All those tomatoes were considered as unhealthy which showed the signs of bacterial or fungal infections, sun-damage or Ca spots. A sample consisting of 20 ripe berries were taken from each parcel. These samples were pressed by a juicer. We checked the Brix° by a portable automatic refractometer (Hanna HI96801).

Results and assessment

Average yields were calculated from the four repetitions per treatment, while the average refractions were determined by the four repetitions per harvest date. As it can be seen in Figure 1 the most ripened berries came from the non-irrigated parcels. Proportion of green and burgeoned fruits increased as a result of improved water supply. The share of cull berries remained unchanged following the treatments.

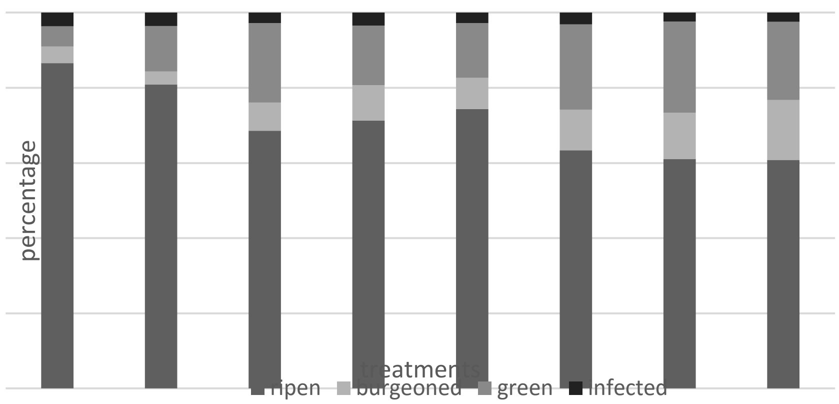

Figure 1 Distribution of ripe, burgeoned, green and cull fractions (in percent of water and K treatments)
(1) treatments, (2) percentage

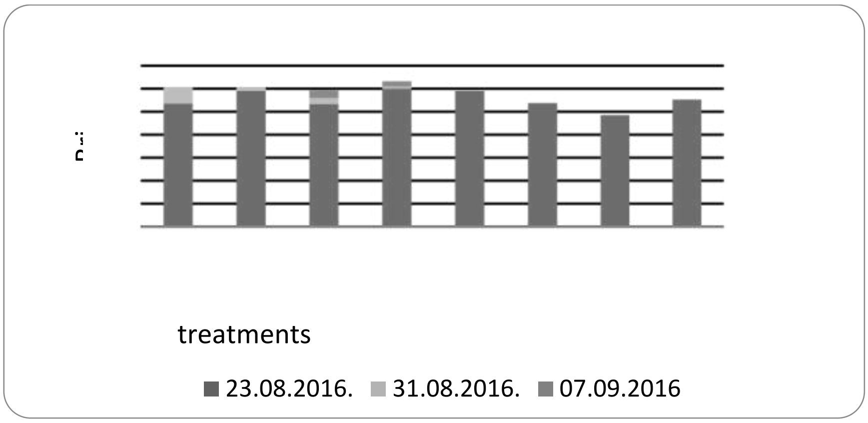

Figure 2 Brix values of water and potassium treatments in three havest dates.
(1) treatments, (2) refraction

The highest level of refractions (Figure 2) were reached in samples taken from the 50% water supply parcels at the third harvest date. It can be observed that refraction values are lower in parcels with good water supply, while higher in areas under water stress. Total average yields (Table 1) also clearly represent this tendency: the better the water supply is in a given parcel, the more yield it will produce.

	total	**ripe**	**burgeoned**	**green**	**unhealthy/cull**
Water 0, Potassium 100	413,86	362,1	18,72	22,58	10,46
Water 0, Potassium 0	441,23	359,27	15,84	53,84	12,28
Water 50, Potassium 100	469,09	323,18	35,4	99,7	10,81
Water 50, Potassium 0	407,88	293,1	38,56	65,36	10,86
Water 75, Potassium 100	445,42	333,48	37,14	65,18	9,62
Water 75, Potassium 0	591,72	377,24	64,24	134,84	15,4
Water 100, Potassium 100	655,86	401,88	81,06	159,7	13,22
Water 100, Potassium 0	753,76	458,21	120,15	156,78	18,62

*Table 1*Yield (kg) regarding different water and potassium combinations
(1) yield, (2) treatments

	total yield	refraction%
Water 0	7,56	5,70
Water 50	8,26	5,80
Water 75	10,03	5,32
Water 100	12,56	4,50
$SzD_{5\%}$	1,98	0,30

Table 2 Means of total yield and Brix values at four irrigation levels (0, 50, 75 and 100%)
(1) total yield and refraction, (2) treatments

In case of parcels treated with water and 100% potassium we have examined the relations between the total yield and Brix° (Table 2). From the aspect of average yields it can be stated that there was no significant differences between 50% and non-irrigated parcels, while the ones where 75% and 100% irrigation was applied show remarkable distinctions when compared to either each other or the other parcels. As for refractions the same tendency can be observed with totally inverse relation. It can be concluded that the correlation between Brix° and total yield is negative.

Conclusions

Different levels of water supply result more dominant differences in both productivity and the amount of water solublesolids than potassium supply. Irrigation providing 100% of the calculated specific water demand leads to outstanding total yield, although the amount of marketable products rises in a more moderate extent. This increase of the yield mainly caused by the greater number of yellow and green berries. The highest Brix values are measured under strong and medium water stress, while intensive irrigation drastically reduces water soluble solids that is unfavourable from the aspect of processing. The preliminary experiment can be assessed as successful: the settings can be further examined by utilising waste materials deriving from hydroponics.

Summary

The application of “cut off” method, i.e. the water deprivation in the last 3 to 4 weeks before the harvest in order to increase the amount of water soluble solids and other quality parameters is a widespread solution in the largest production areas of the world (e.g. California and Italy) where this procedure does not lead to considerable yield loss.

The “cut off” method cannot be applied successfully in Hungary. During the main harvesting period (between 10 August and 15 September) and the preceding 3 to 4 weeks rains often disturb the process of ripening. The objective of our examinations is to find out whether water deficit irrigation can be effectively applied on the sandy soils of Kecskemét.

In 2016 we studied the impacts of four different irrigation levels in the Kecskemét Station of the National Agricultural Research and Innovation Centre Vegetable Crop Research Department. We used Unirosso F1 tomato variety. Water doses were determined by the specific water demand of this plant and the data received by using tensiometers.

Considerable differences were revealed regarding harvestable yields and Brix between non-irrigated parcels (7.56 kg/m^2, 5.70 %) and those receiving the maximal amount of water (12.56 kg/m^2, 4.50 %). Water deficit treatments resulted proportional changes in productivity between the two extreme values.

During the preliminary experiment it was determined that these settings are suitable for conducting examinations on the secondary utilisation of waste materials coming from hydroponic plant production.

Keywords: tomato, irrigation, potassium, refraction, Brix°, plant forcing, waste

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ESTABLISHING A CLOSED GROWING SYSTEM APPLYING LED LIGHTING –FIRST EXPERIENCE

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Introduction

In countries of well-developed horticultural technologies cultures representing high individual value are, in increasing extent, grown under perfectly controllable environmental conditions. This makes the whole production more predictable and reliable. One part of this process is providing optimal lightconditions. The use of supplementary lighting in large-scale vegetable forcing has started in the mid-90s. The development of LED lighting devices gave new impetus to this technology. LEDs are more cost-effective to operate and they allow to set spectral distribution ideal for the given plant cultures. Especially in South Asia more and more producers start using installations where the light requirement of plants is satisfied solely by artificial lightings, with the total exclusion of sunlight. Researches related to the use of LED lighting have been initiated by several Hungarian scientific institution, too.
Our long-term plan is to develop individually built LED lighting devices for different horticultural plant cultures. In order to achieve this we aimed to create a closed growing systemin which we can conduct the necessary experiments. For this we had to implement a pre-experiment so as to examine whether it is possible to grow plants in this growing system by using exclusively artificial LED lamps for lighting.

Literature review

Supplementary lighting used to be provided by different types of wide spectrum lamps, such as metal halide, CFL, HPS, fluorescent tubes, high pressure sodium lamps, etc.Their common main disadvantage is the poor efficiency, since the majority of the electric energy is transformed into heat (Mitchell and Stutte, 2015; Mitchell et al., 2015).Thanks totheadvancement of technology LED lights provide a more viable alternative solution in the field of plant lighting. During the past 15 to 20 years their price has been considerably reduced, their life expectancy and brightness grew, while the supply was broadened as regards of available wavelengths. The single most effective way of growing plants is to provide them with wavelength and brightness optimal for their development. In this way we can achieve adequate growth by the least possible amount of used energy (Kozai et al., 2015; Mitchell and Stutte 2015). In this aspect LED lamps offer the largest advantage compared to any other types of lighting. LEDs have a much narrower output frequency, thus it is possible to target the physiologically important wavelengths with high accuracy (Massa et al., 2008). By using LEDs supplementary lighting can be more effective; for exampleHidaka et al. (2013) experienced that in case of growing strawberry LED lamps resulted larger number of berries and higher average berry weight compared to fluorescent lighting.

These LEDs are used in wide range for more and more specific purposes regarding plant production (Mitchell et al., 2015; Sipos et al., 2017). One of these objectives is their application in closed plant production systems, the so-called plant factories. By using this method production can be implemented in cities, near the consumers all year around, reducing transportation costs and increasing the freshness of goods provided for the buyers (Kozai et al, 2015).

Material and methods

As a first step the growing room necessary for implementing the preliminary experiments has been set up in one of the basement laboratories of St. István University in Gödöllő. In order to control the temperature the room is climatized.The useful floor space of the laboratory is 21 m^2in which we have created 300 cm long, 30 cm wide and 230 cm high growing rack by using aluminium profiles (Figure 1). The growing rack can be divided into two equal-sized parts by a screening plate. It provides the possibility of using different kinds of lighting and comparing the results, while plants in both halves of the rack receive the same nutrients. Due to the installation of the rack the distance between the lamps and the plants can be adjusted.

Figure 1 The set up growing device

An automated nutrient solution system has been developed for the production. The solution has been mixed in a barrel standing in the corner of the room. A pump transported the liquid to the plants by using dripping emitters at the ends of the pipes (see Figure 1). Drain has been collected by using the channel at the bottom of the rack and removed from the room with the help of a condensate pump.

We looked for a plant that is relatively small-sized, develops well under 300 μmol/m^2/s Photosynthetic Photon Flux Density (PPFD) and provides good chance for observing both vegetative and generative growing phases. By taking all these requirements into account we chose strawberry as the subject of the experiments.
Seedlings of the Clery variety were planted in 10 October onto 20 cm wide and 100 cm long Dutch Plantain coco peat rooting media. Altogether 30 plants were used distributed evenly between the two ends of the growing rack. Prior to the growing all rooting media were filled in with growing solution as instructed. The automatic irrigation machine (G-Systems Engineering digital water cycle timer) has been set to give water to the plants for 40 to 45 seconds in every two hours during the lighting period. EC of the growing solution was 2.4 mS/cm. No plant protection treatments have been applied during the production. Offshoots were removed from the plants. Pollination of the flowers were made by brush application. Weight of the harvested berries was measured individually by using a KERN PCB laboratory scale. After sorting a group of eight people was asked to qualify the taste of the strawberries.
Lamps were placed 90 cm above the leaf-level of the plants. The duration of lighting was set to 12 hours by using the G-Systems Engineering Timer Box. Plants were lightened from 7 am to 7 pm. Two types of commercially available LED growing lamps were acquired for the experimental production. Both types were presumed to be suitable for such kind of task. One of the two lamps (hereinafter referred to as Lamp A) had nine light sources of different wavelengths, while the other one (hereinafter referred to as Lamp B) included only five wavelengths. Lamp A and Lamp B consume 140 watts and 130 watts of electrical energy, respectively.
Luminous intensity of the lamps was measured at the leaf level by an Extech SDL 400 luminometer. Different spectrums of the two LED lamps were individually analysed by an Ocean Optics FLAME-S-XR1-ES spectrometer in order to reveal how light intensity was shared among the certain wavelengths.

Results and assessment

We have received the expected results during the examination of the lamps' spectrum.In case of Lamp A and Lamp B nine (410, 440, 464, 534, 570, 611, 635, 663, 737 nm) and five (440, 460, 613, 637, 663 nm) peaks were detected, respectively. Based on our measurements conducted on Lamp B 31% of the luminous intensity belonged to the blue spectrum, while 69% to the orange and red spectrums. As for Lamp A the more spectral peaks resulted much wider and more complex distribution: 4% violet, 25% blue, 2% green, 2% yellow, 65% orange-red and 1% far red (see Figure 2). As it can be seen, the red:blue ratio was higher when using Lamp A. Luminous intensity measured at a 90 cm distance from the light sources was .3700 lux in both cases. Depending on the applied conversion factor it is equivalent to the PPFD of approximately 50-60 μmol/m^2/s.It is considered a rather low value from the aspect of plant production.

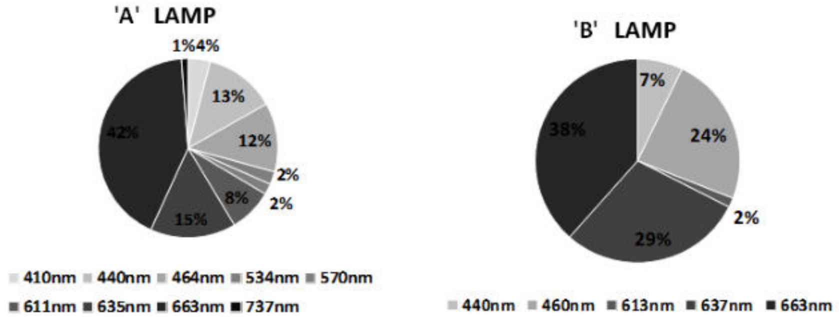

Figure 2 Wavelength distribution of the two applied LED lamps

In spite of the low luminous intensity strawberries started to develop well under both types of lamps. No visible distinction could be made regarding the growth of the plants during the first few weeks of the experiment, until the closure of the leaves. However, at the next phase the lowest leaves of plants under Lamp B started to wither, while no such phenomenon was observed under Lamp A. Furthermore, leaves lightened by Lamp B grew visibly smaller. Therefore, height of the canopy fell short when comparing that of plants growing under Lamp A. The latter strawberries appeared to be perfectly healthy. Flowering occurred under both light sources, all 30 plants blossomed and bore fruits during the experiment. It means that all vegetative and generative development stages can take place under either type of used LED lamps. Manual pollination has not been 100% successful, since some fruits became small and unshapely.

First harvest has been accomplished in 8 December, two months after planting.At that time the number of berries picked from the plants under Lamp A was considerably higher, but the average size of the fruits was smaller (see Table 1). As for the total weight plants lightened by Lamp A were producing 25% more yield. During the second harvest the volume was generally lower, but plants under Lamp B provided the majority. The use of Lamp A altogether resulted 10% more yield and 55% more berries. It also means that the average weight of one strawberry was 41% less than that of under Lamp B. Average yield per plant remained under 20 g that is an extremely modest result – less than one tenth of what can be expected of an early frigo seedling. It can presumably be the consequence of the low light intensity and the inadequate pollinating. The plants were predominantly vegetative types and produced large amount of leaves compared to the yield they give.

Light conditions influence the taste of the strawberries and, of course, their consumer evaluation (Watson et al, 2012). During the tasting the panel consisting of eight people unanimously voted that the taste of strawberries grown under Lamp A was more pleasant. Therefore, the LED lamps had impacts not only on the production parameters but also on the taste of the final products.

Harvest Time (1)	'A' Lamp (2)			'B' Lamp (3)		
	Crop weight (g) (4)	Crop piece (5)	Average weight (g/db) (6)	Crop weight (g) (4)	Crop piece (5)	Average weight (g/db) (6)
2017.12.08.	420	74	5,67	334	41	8,14
2017.12.20.	58	26	2,23	98	22	4,45
2017.12.27.	21	3	7,00	13	2	6,50
2017.12.30.	6	1	6,00	13	2	6,50
Summ (7)	505	104	4,86	458	67	6,83

*Table 1*Effects of two commercial LED lamps on yield parameters of strawberry 'Clary'
(1) harvest date, (2) LED Lamp A, (3)LED lamp B, (4) Total weight (g), (5) Number of fruits, (6) average fruit weight, (7) Altogether

Conclusions

The preliminary experiment justified that strawberry can be successfully grown in the established closed production system. We could achieve that plants went under their entire vegetative and generative development stages using either of the LED lamps: the strawberries flowered and bore their fruits. It could be clearly seen that leaves were in better condition in case of plants lightened by the LED lamphaving a wider spectrum. Choi et al. (2013) concluded that illumination combining more types of LEDs is more favourable for the strawberry. Leaves of the lower level can presumably maintain photosynthetic activity due to the presence of green light provided by Lamp A (Kim et al, 2004). Another conclusion is that the development of larger leaves is the result of the infra spectrum also present in the light of Lamp A (Mitchell et al. 2015). Violet light can have positive effect on the taste of the fruits (Lee et al, 2016). The large number of amorphous strawberries can be attributed to the inadequately implemented manual pollination, thus we have to improve our technique in this field. It is also important to increase the intensity of light inour next experiment. At a later stage we would like to conduct experiments with custom-built LED lamps while considerably enlarging the scope of the examined parameters.

Summary

Application of LED lighting becomes more and more widespread in countries of advanced horticultural practices. These lamps are used both as supplementary lightings in traditional greenhouses and as exclusive light sources in closed production systems. Our objective was to create a production room where experiments regarding LED lighting can be implemented. As a preliminary experiment we tried to grow strawberry plants using two different, commercially available LED lamps. We can conclude that this preliminary experiment has been successful, since we were able to harvest fruits from plants illuminated by either of the two lamps. The type of light source affected the volume of the yield, the number of harvested berries as well as the size of the fruits. Based on our experience it can be said that the wider spectrum lamp using nine different LEDs had more favourable impacts than the other one which consisted of only five types of LED.

Violet, green and far red spectrums supplementing red and blue had a beneficial effect on the strawberry plants.

Keywords: spectral distribution, strawberry, yield parameters

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This publication has been completed within the framework of project no. EFOP-3.6.1-16-2016-00016 focusing on training and research profiles with intelligent specializations on the Szarvas Campus of St Istvan University involving agricultural water management, hydroponic plant systems, alternative crop production related to improving precision machinery in agriculture.

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ESTABLISHMENT OF A CLOSED PLANT PRODUCTION SYSTEM WITH LED LIGHTING – FIRST RESULTS

Abstract

LED illumination is gaining ground in countries having the most advanced horticultural production technology. Both as supplemental lighting in conventional greenhouses and as a sole light source in closed plant production systems. Our objective was to establish a closed plant production system where experiments with LED lighting can be conducted in the future. As a preliminary trial, strawberry plants were raised under two commercially available agricultural LED lamps. The trial was successful as ripe berries could be harvested from the plants under both lamps. Type of the LED lamp have affected the yield, the number of harvested berries and the size of the berries. Based on our first experiences, application of the LED lamp containing nine kind of LEDs with different wavelengths and hence having wider spectral distribution, was more favourable than the other lamp containing just five different LEDs. Violet, green and far red LEDs supplementing the blue and red LEDs had favourable effect on strawberry plants.

Keywords: spectral distribution, strawberry, yield parameters

Salinity effect on hydroponically grown lettuce types

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Introduction

Lettuce (*Lactuca sativa* L.) is one of the most popular vegetables, and consumed vegetables by people in the world (Bozkurt and Bozkurt, 2011). Lettuce is an economically important salad vegetable next to tomato (FAOSTAT, 2012). Not only is lettuce a home garden-grown vegetable, but it can be also grown in hydroponic systems (Rubatzky and Yamaguchi, 2012). Although lettuce is a popular vegetable, lettuce has no longer considered as a nutritious food. The reason is that lettuces have high water content up to 95% (2014; Shargil et al. 2016).

In this context, most farmers are searching new techniques for best quality lettuce production. Greenhouse and soilless cultivation are the most efficient ways to achieve maximum yield in minimum time with excellent quality. One of the mostly modern systems to thrive lettuce production is hydropony. Therefore, hydroponic system might assure, if correctly managed, higher yields, better quality and better hygienic-sanitary characteristics of the produce (Jesus et al. 2017). Many farmers are adopting soilless cultivation in order to both avoiding the phytosanitary problems and controlling more precisely the nutrient solution in particular with regard to the content of nitrates (Miceli et al. 2003).

Since the discovery of the side effects of excessive nitrate on human, nitrate becomes a great concern nowadays. High nitrate content in lettuce can cause serious issues to human (Ikemoto et al. 2002; Ishiwata et al. 2002).

Salinity is another constraint to vegetable production. Vegetables are generally more salt-sensitive than grains or forages (Shannon and Grieve, 1998). It is also worth mentioning that various investigators proposed several methods of calculating a nutrient solution satisfying particular requirements, which are given as target values such as electricity conductivity (EC), nutrient concentrations, relative proportions of nutrients, etc. This method of calculating nutrient solution, if not properly coped, may increase EC, which might prime salinity in hydroponic systems. Taking into account salt concentration when preparing for nutrient solution is really vital because lettuce is considered to be moderately salt sensitive, with a threshold EC 1.3 dS/m (Ayers et al. 1951; Shannon and Grieve, 1998).

It is important to profile the important bioactive compounds of lettuce such as chlorophyll content to improve antioxidant compounds, and nitrate in nutrient intake among different lettuce varieties. Regarding the above facts, the goal of this investigation was to compare fresh weight and bioactive compounds (chlorophyll content and nitrate) in saline and non-saline conditions.

Literature review

According to the World Atlas (2017), the United States, India, Spain and Italy rank top leaders in lettuce production. In Europe, the top 5 producers of lettuce are Spain, Italy, France, Germany, and the Netherlands (EUROSTAT, 2017). The European Commission Scientific Committee for Food established, in 1995, the Acceptable Daily Intake (ADI) of nitrate ion as 3.65 mg/kg body weight

(equivalent to 219 mg/day for a person weighing 60 kg), whereas the Joint Expert Committee of the Food and Agriculture (JECFA) Organization of the United Nations/World Health Organization (WHO) established the Acceptable Daily Intake of nitrate as 0 – 3.7 mg/kg body weight (Speijers et al. 1987). Therefore, assuming a 60 kg body weight, ingestion of only 100 g of fresh vegetables with a nitrate concentration of 2500 mg/kg fresh weight exceeds the ADI for nitrate by approximately 13%. For a real assessment, however, nitrate content in all other sources as well as their average daily consumption amount must be taken into account. On the other hand, the USA Environmental Protection Agency (EPA) Reference Dose (RfD) for nitrate is 1.6 mg nitrate-N/kg body weight per day (equivalent to about 7.0 mg NO_3 weight per day) (Mensinga et al. 2003).
The concentration of nitrate in lettuce varies according to the varieties and cultivation conditions (Paulus et al.2012). Other factors such as light intensity, temperature, relative air humidity, and growing season can also affect the nitrate accumulation in lettuce leaves (Guimarães et al. 2010). According to Sandri et al. (2006) and EFSA (2006) for lettuce cultivated in greenhouse, the limit is 4500 mg/kg of fresh weight FW in the winter and 3500 mg/kg of FW in the summer.

Materials and methods

Plant materials and growing system

The experiment was conducted at the Szent István University, Faculty of Horticultural Science, Department of Vegetable Growing, Budapest. The experiment was set up in the Department's fitotron. Different types of lettuces were used: butterhead, loose leaf or lollo and oak leaf. A total of 7 varieties of lettuces were used as plants materials from RIJK ZWAAN Company. Those varieties were Sintia (green butterhead lettuce), Cencibel (triple-red loose leaf lettuce), Corentine (red loose leaf lettuce), Limeira (green loose leaf lettuce), Attirai (red oak leaf lettuce), Kiber (green oak leaf lettuce), Rouxaï (quarto red oak leaf lettuce). Lettuces were grown in growing chamber or Sanyo fitotron Versatile Environmental Test Chambers with Humidity Control Model No.MLR-351H. The first experiment which is the saline condition, EC up to 10 dS/m, was carried out from May 15 to July 10, 2017. The second experiment, non-saline condition, EC <1.3dS/m, was carried out from October 26 to December 13, 2017. Each variety of lettuce received the same type and the same quantity of fertilizer. A total of 3 types of fertilizers were used: Fertilizer starter (15-30-15), Ferticare (14-11-25), Calcinit: 0.02%. The experiment was organized in a randomized block design with 5 blocks since 5 replicates were done. Each of the 7 varieties had been treated within the same conditions (temperature, relative humidity, lightning, and quantity of fertilizer). Photoperiodism was 12 h /12 h-day/night with 4000 klux for the light intensity and relative humidity was set 85%. Temperature was regulated to 20°C/18°C (day/night). It is important to notice that those conditions were unchanged from the beginning until the end of the trial. Water was given manually and neither pesticides nor phytosanitary product were applied to lettuce plants during all the experiment.

Fresh weight

Fresh weight measurement was immediately recorded after harvest. Fresh weight was measured without the lettuce roots, and it was be expressed in g/plant for each sample.

Chlorophyll

Chlorophyll content of lettuces was measured with a chlorophyll meter. For the experiment, 5 measurements were taken on a randomly chosen big leaf and the SPAD meter showed up the average automatically. It was expressed in SPAD value.

Nitrate

Nitrate measurement was performed by two UV-VIS spectrophotometers, which were PC-driven, Thermo Scientific (Walthman, Massachusetts, USA). A total 5 g of grinded lettuce sample was needed.

For the evaluation, VISION pro V2.02 software program was used. Based on the absorbance (at 410 nm wavelength) of the calibration solutions, the concentration-absorbance relationship was determined. By knowing the equation of the linear relationship, the nitrate concentration of the samples could be given based on the absorbance of the samples.

Statistical Analysis

Data were subjected to two-way analysis of variance (ANOVA) in SPSS with two fixed factors: variety 7 levels (Sintia, Cencibel, Corentine, Limeira, Attirai, Kiber, Rouxaï) and treatment with 2 levels (saline and normal). Normality was checked by Kolmogorov-Smirnov and Shapiro-Wilk. Homogeneity of variances by Levene's Test. Factors varieties were separated by Tukey's Post Hoc or Games-Howell's Post Hoc.

Results and evaluation

Fresh weight

There was a highly significant treatment effect (saline and non-saline) on the fresh weight ($F (13, 56) = 73.86$; p value <0.001). In addition, there was a significant variety effect on the fresh weight ($F (13, 56) = 4.47$; p value <0.01). However, there was no significant interaction effect ($F (13, 56) = 0.94$, $p=0.47$). Results showed that when lettuces were exposed to saline conditions, there is a significant decrease on average by 42% of the fresh weight. Reduction in plant growth under saline conditions is a common phenomenon (Ashraf and Harris, 2004). Lessening of biomass production is a general response of glycophytes such as lettuces (Blasco et al. 2013) to salt stress (Munns, 2002). The findings were similar to those reported by Miceli et al. (2003). Andriolo et al. (2005) also found that when exposed to a solution with an EC of 2.8 dS/m, yield decreased linearly by 16.5% per unit EC. This significant decrease in fresh weight with increasing EC levels was also confirmed by the results published by Ouhibi et al. (2014) and Schrader (2017).

Chlorophyll content

There was a highly significant varieties effect on the chlorophyll content $F (13, 56) = 10.40$; p value <0.001. Besides, there was a significant treatment effect on the chlorophyll content $F (13, 56) = 4.97$; p value <0.05. However, there was no significant interaction effect between varieties and treatment on the chlorophyll content $F (13, 56) = 0.80$, $p=0.57$. In general, lettuces accumulated high chlorophyll when exposed to salinity compared to the normal conditions. An increase pattern of chlorophyll by 10% was detected. Though, for Corentine varieties, a slight decrease in chlorophyll (8%) which was significant was noted. Salinity increased SPAD values in most genotypes, indicating higher chlorophyll content. Salt-stressed lettuce was darker green (Shannon et al. 2000; Ayers et al.1951). Research conducted by Wang and Nii (2000), Pérez-López et al. (2015), Xu and Mou (2015), and Alam et al. (2015) supported that there was an increasing pattern in chlorophyll contents with the increasing of salinity levels. Misra et al. (1997) also concluded that salt stress induced and increased the chlorophyll content, which could be due to an increase in the number of chloroplasts in stressed leaves.

Nitrate content

There was a highly significant variety effect on the nitrate content $F (13, 56) = 25.66$; p value <0.001. Besides, there was a significant treatment effect on the nitrate $F (13, 56) = 6.80$; p value <0.05. Additionally, there was a highly significant interaction effect between varieties and treatment $F (13, 56) = 25.89$; p value <0.001. Higher levels of salinity showed a tendency to increase leaf nitrate in general. This result is thereby in conformity with the findings of Chung et

al. (2005), Eraslan et al. (2007), and Paulus et al. (2012). Furthermore, Jin et al. (2004) stated that nitrate accumulation in the lettuce was increased by 18.6% in saline conditions, which were in agreement with our findings. However, this increase is smaller compared to the present research (increase of 39%). Indeed, nitrate accumulation in plants is generally associated with a direct relationship with nitrogen availability (Kerbirou et al. 2013). High nitrate accumulation could be further explained by high nutrient uptake by lettuce. Lettuce needs to keep a high turgor pressor resulting in this leafy vegetable leaning toward accumulating nitrate in their leaves (Nicola et al. 2004; Coronel et al. 2008; Fontana and Nicola, 2009; Fallovo et al. 2009; Manzocco et al. 2011). The tendency of the increase in nitrate content with the higher levels of salinity can also be explained by the osmotic adjustment so that plants can absorb water under conditions of low total water potential (Chung et al. 2005). Nevertheless, Tesi et al. (2003) are in disparity with the results from the current study by indicating that rising salinity reduced nitrate accumulation in the leaves of lettuce. This reduction in nitrate contents in lettuce cultivars under saline stress were also reported by Pérez-López et al. (2015). Those investigations are therefore in partial conformity with results which showed that a decreasing pattern in nitrate for the lollo type lettuce (Corentine) when exposed to saline conditions. In fact, investigations conducted by Borghesi et al. (2013) on lettuce (*Lactuca sativa* L.) var. "Lollo rosa" grown in a floating hydroponic system ascertained that part of the present experiment. On the other hand, Miceli et al. (2003) found in lettuce growing in hydroponic system a decrease of 2218 mg/kg to 1634 mg/kg of FW in nitrate content of the leaves and an increase level of salinity of the nutrient solution from 1.6 to 4.6 dS/m,. This reduction in nitrate is probably beneficial to human health according to Fernández et al. (2016).
The highest nitrate contents in normal and saline conditions were 1894.24 mg/kg (Corentine lollo) FW and 4395.80 mg/kg FW (Cencibel lollo), respectively. Both values did not exceed the limit imposed by the Regulation in 2006. It is worth mentioning that for the nitrate content of butterhead (Sintia) and oak leaf lettuce was higher if compared to the research conducted by Alexander et al. (2008). Nitrate contents of the aforementioned lettuce types were 2026 mg/kg FW and 1534 mg/kg FW, respectively.

Conclusions

The cultivation of lettuce (*Lactuva sativa* L.) in hydroponics systems under salinity stress was observed to effect the yield. It did influence characteristics like fresh weight, chlorophyll and nitrate contents when the electric conductivity of the nutrient solution was up to 10 dS/m. However, the use of salinity could decrease another important quality factor for the lettuce, namely the reduction of nitrate contents in leaves in particular for the lollo type. These results suggest that the use the lollo type variety like Limeria and Corentine in as much as hydroponic system presents risks of EC level that can lead to salinity.

Summary

Lettuce (*Lactuca sativa* L.), the most popular vegetable, is among the mostly consumed vegetables by people in the world and has a greatly economic importance. Not only do most people grow up lettuces as a vegetable in their own home gardens, but they also are especially grown in hydroponic systems. Hydroponic system might assure, if correctly managed, higher yields, better quality and better hygienic-sanitary characteristics of the product. The goal of this investigation is to compare fresh weight, bioactive compounds (chlorophyll and nitrate contents) of different lettuce types under saline conditions. Results showed that there was an overall decrease in fresh weight of lettuces in saline conditions. Under saline conditions, lettuces accumulated chlorophyll contents.

Results stated that lettuces accumulated more in overall nitrate in saline conditions than in normal conditions. This accumulation of nitrate is not significant for Attirai variety. Although there was an increase in nitrate in saline conditions, a significant decrease in nitrate content was reported for Corentine and Limeria (lollo type).

Keywords: hydroponics systems**;** electricity conductivity; saline; nitrate; chlorophyll

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Changes of nutrient values in hidrophonic tomato growing system

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2

Introduction

Plants produce the compounds of their bodies from carbon dioxide received from the environment and using energy. Therefore, almost every plant reacts to the increase of the CO_2content by more intensive photosynthesis and biomass-production.Outdoor plants obtain the necessary amount of carbon dioxide from the atmosphere that has a CO_2 concentration of approximately 300 ppm (0.03 vol%). In tightly sealed greenhouses the required amount of carbon dioxide can be provided by ventilation. However, the issue of CO_2 fertilisation has been emerged in the 1950s in connection with vegetable forcing. This practice has become an integral part of forcing in numerous countries during the past 20 to 25 years. In our experiment we tried to learn how the growing conditions of vegetable forcing, CO_2 content in particular, influence content value.

Literature review

Examinations on tomato are emphasised in the past few years as this vegetable is connected to healthy eating. It is mainly due to its lycopene content providing red colour to the fruits. Tomato contains more lycopene (60 to 64% of its total carotenoid content) than any other cultivated plants. Some researches concluded that lycopene helps preventing several types of tumor diseases (Lugasi et al, 2004) as well as delaying the early ageing of the skin thanks to its antioxidant characteristics.

Lycopene content of tomato fundamentally depends on (Helyes et al, 2002) the variety (industrial tomatoes have significantly higher amount of it) and the environmental factors, particularly light and temperature conditions during the burgeoning and ripening stages. Maturity at the time of picking and the date of the harvest also play a role in setting the amount of lycopene.

According to Deák et al. (2012) the key for the biosynthesis of carotenoids is presumably the low temperature. It reflects to the researches of Ishida (1999) who conducted experiments on cherry tomato kept in greenhouse and concluded that lycopene content was three times higher at 16 °C than at over 25 °C. Examinations of Helyes L. (2007) also justified this theory. Low temperature favours lycopene synthesis, although it has an adverse effect on producing vitamin C. Average lycopene content of berries exposed to

direct radiation is approximately 20% higher compared to those not receiving such treatment. In outdoor production where support systems are used those tomatoes receiving more direct insolation at higher temperature showed a 35% decrease as regards of their lycopene content.
Ventilation is a kind of compromise between the access to carbon dioxide and temperature in greenhouses without artificial CO_2dosing systems. Stanghellini and fellow researchers (2009) came to the conclusion that, considering the close connection between temperature and production, the best and most profitable choice for producers is to use the least possible ventilation (taking the limitations of air moisture and temperature regulation into account) and apply bottled CO_2 for reaching at least the outside concentration. In this case the CO_2 does not leave the system, so this level ensures that all the carbon dioxide be assimilated.

Jarquín-Enríquez et al. (2013) studied the effects of light on the colour development of tomato and on the accumulation of lycopene. They used two greenhouses with different covers (double layer polyethylene K50 Clear + K50 IR / AC and flat glass with 4 mm thick 15% CaCO3 coating) and made experiments in several production phases. They found that the amount of light the tomato berries received after the ripening had started is of key importance, since it is able to increase the biosynthesis of lycopene. More of this compound has been accumulated in the fruits receiving larger amount of light exposure. These tomatoes had better colourisation and visual quality. It has to be considered whether to use the techniques of whitening, washing and shading in order to regulate temperature in greenhouses if the aim is to increase the colour intensity and the accumulation of lycopene in tomatoes.

Impacts of increased carbon dioxide level on yield have been examined by several experts under various atmospheric concentration level and other unfavourable producing conditions (e.g. plants infected by pathogens or stressed and salty soil etc.). Research results show considerable standard deviation, nevertheless they generally prove the favourable influence of higher carbon dioxide level. Among others Ziska et al. (2001) grew tomato at 500 ppm of night-time atmospheric CO_2 concentration. Total biomass production was 10% higher than in case of those tomatoes (control group) cultivated at 370 ppm CO_2 concentration.

As a response to increasing amount of consumer complaints Zhang et al. (2014)examined the factors influencing the content value of tomato grown under greenhouse conditions. This plant is very often tended in greenhouses in China so as to ensure early harvest and satisfy consumer demands. However, examinationsshow that the quality factors, such as colour and taste as well as the average content of ascorbic acid and carotenoids are generally poor. To react to these widespread complaints Zhang et al. carried out a greenhouse experiment in which the 800 to 900 ppm CO_2 concentration has been theonly variable factor compared to the value of 100 to 250 ppm daytime concentration of the control greenhouses. This simple change made in the growing conditions resulted a greenhouse effect and led to the considerable increase regarding the concentration of health-preserving compounds – including lycopene, beta-carotene and ascorbic acid. The heightened level of carbon dioxide also improved the taste of tomatoes that is due to the amount of sugars, titratable acidity and the sugar/acid ratio. It was also stated that the raised CO_2 level helped all other organoleptic attributes, such as colour, tightness, aromas and other features of the tomato berries.

Material and methods

The crops involved in the experiment can be found in Szarvas, in the Galambos educational facility of St. István University. A greenhouse built in 2016 with almost 2,000 m^2 gross and 1,800 m^2 net area and 6 m height was used for the research. The greenhouse has two symmetric and separablearea where it is possible to set different climatic conditions. The system for providing CO_2 has also been installed. It consists of 12 connected bottles, so-called bündels, that have electronic switch valves through which the level of CO_2 can be regulated inside the greenhouse. Perforated KPE pipes with the diameter of 20 mm ensure the even distribution of carbon dioxide all along the rows.

The tomatoes have been planted in 16 February 2017. The selected Aruba F1 variety has become one of the most popular vine tomatoes cultivated in Hungary during the past years. Its main positive features are the spectacular sepals, deep red colour and longevity. This latter characteristic is outstandingly important for commercial supermarket chains.

Seedlings were grown in 10 by 15 cm rockwool cubes in Szentes. They were transferred to the greenhouse when reaching six-leaves stage. Each rockwool cube has two plants to grow. These tomatoes were planted in once used coco peat growing medium maintaining the density of 3.8 plants/m^2.

A climate computer operates in the greenhouse making it possible to constantly record the measured data. Thus, inside radiation, temperature and air moisture at the top of the plants in both blocks of the greenhouse as well as CO_2 concentration at 2 m height have been observed and recorded in 15 minute intervals during the entire production period. CO_2has been released into the greenhouse on an occasional basis in 2017.

During the experiment, from week 27 on the following data were continuously recorded: a) weekly growth, b) leaf length, c) number of leaves, d) leaf width, e) leaf area, f) stem diameter, g) vine distance, h) flowering vines, i) fruit setting vines and j) yield. These parameters were examined in both climate blocks involving 12 plants in four rows regarding each block.

Content value of tomatoes (lycopene, 13-cis-lycopene, beta-carotene, lycoxanthin-lutein, phytoene, phytofluene and total carotenoids) has been examined in the laboratory of St. István University Regional University Knowledge Centre. Samples were picked three times during the production period at the following dates:
1. 11 May (week 19)
2. 3 August (week 31)
3. 29. September (week 39)

Results and assessment

Ripening cycle of tomato is approximately 60 days from flowering to reaching full ripened state of berries, so we examined a 60-day-long period before harvesting. Insolation and CO_2 concentration within the greenhouse as well as outside and inside temperatures were recorded (Table 1).

Date of harvest	total insolation (J/cm2)[1]	average outside air temperature (C°)[2]	inside temperature (C°)[2]		CO_2concentration (ppm)[2]	
			Block1	Block2	Block1	Block2
11 May 2017 (week 19)	58509	9.3	17.2	17.0	440.0	480.7
3 August 2017 (week 31)	91452	19.4	19.4	19.4	456.8	483.6
29 September 2017 (week 39)	67976	18.2	18.5	18.7	454.1	494.8

1 Total amount of 60 days preceding harvest.
2 Average of 60 days preceding harvest.

Table 1. Measured radiation, CO_2 concentration and outside and inside temperature in the greenhouse, 2017

By comparing data from May and September it can be seen that, beside almost the same amount of total insolation, the average daily temperature was significantly lower in May. The difference is nearly twofold: the mean temperature was approx. 9 °C higher in September. In spite of this difference the greenhouse provided constant and balanced temperature for the plants. The alteration between the lowest and highest value was only 1.4 °C. While inside temperature data were very similar regarding the two separate parts (Block1 and Block2), CO_2 concentration was 5 to 9% higher in case of Block2 (where carbon dioxide was administered on an occasional basis). The level of CO_2 was 60 to 120 ppm higher than the atmospheric concentration (approx. 380 ppm).
The advantage of producing plants at a balanced temperature can clearly be demonstrated by the yields (pieces). This indicator maintains a relatively balanced value until the topping of the plants (weeks 45 and 46).

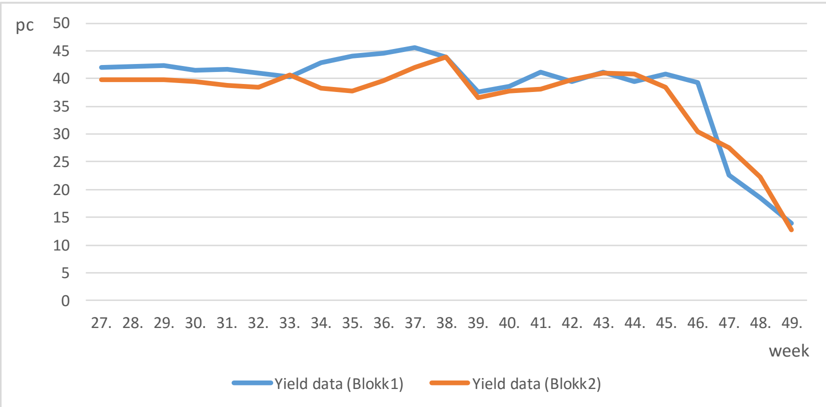

*Figure 1*Weekly yield data in the two climate blocks, 2017

One of the outstanding qualities of Aruba F1 tomato is its deep red colourisation. Sample picked at the first ripening of the plants (week 19) showed high total carotenoid values – including high lycopene content. The second sample harvested at the beginning of August (week 31) proved to have much higher content value. However, the last sample received nearly two months later represented significantly lower content value, falling well short of the numbers seen in case of the May sample.

As for the first and second samples berries from Block2 (where the concentration of $CO_2$was higher) had 22 to 25% higher content value than tomatoes coming from Block1. This difference could not be observed during the examination of the samples harvested in September.

Date of harvest	total carotenoids (µg/g raw material)		lycopene (µg/g raw material)	
	Block1	Block2	Block1	Block2
11 May 2017 (week 19)	613.11	757.82	439.51	548.74
3 August 2017 (week 31)	814.29	993.38	661.00	820.89
29 September 2017 (week 39)	484.11	491.88	380.75	376.73

Table 2 Nutrient contents of the examined Aruba F1 tomatoes

Regarding the period preceding the first two samplings the size of leaf area has not changed notably due to the balanced growing. However, in the 60-day-long period (weeks 31 to 39) before the third sampling (week 39), i.e. in the phase of growing and ripening berries the leaf area decreasedconsiderably, by approximately 30% (based on the highest and lowest recorded values). During the same period we noticed the fall of weekly mean temperature from 23.8 °C in week 31 to 14.5 and 14.6 °C in week 39 (the difference is 39%). No significant differences could be observed between the two climate blocks of the greenhouse in this aspect.

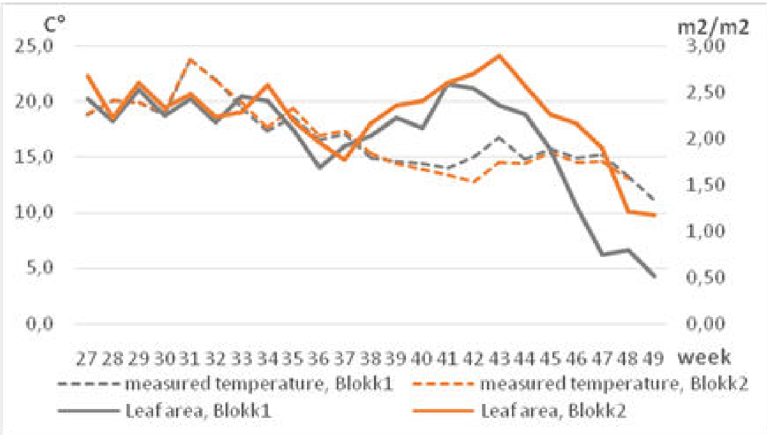

*Figure 2*Changes of leaf area and measured temperature in the two climate blocks, 2017

Conclusions

One of the outstanding characteristics of Aruba F1 tomato is its deep red colour. Based on the measurements it is due to its high content value – especially to lycopene. However, content values showed considerable fluctuations during the examined growing period of 2017. The difference between the highest and lowest recorded values was approximately 50%. Remarkable distinction was also observed between the highest peak in August and the lowest value in September. It can only partly be explained by the decreasing temperature and insolation, since samples from May had higher content values despite the same amount of total insolation and lower weekly mean temperatures. By examining the 60-day-long ripening period it can be concluded that the considerable (-39%) decrease of temperature implied the reduction of leaf area (-30%). Therefore, it can be presumed that these two changes together led to the notable alteration of content values.
Dissimilar content value (regarding lycopene) measured in the two climate blocks (May: +23.6%; August: +23.0%; September: +1.6%) cannot be explained by the fluctuations of total insolation and inside mean temperature, since these parameters were generally the same regarding both blocks. Only the level of carbon dioxide showed considerable difference during the examined period (May: +9.2%; August: +5.9%; September: +9.0%).

Summary

As consumer demands change, beside early availability of fruits and vegetables, high content value becomes more and more expected. Health-enhancing impacts of tomato are, among others, attributed to lycopene, thus varieties containing higher amount of lycopene are sought-after in production.
In 2017 we have examined the content values of Aruba F1 vine tomato grown in the greenhouse of St István University Galambos educational facility. We used the data of plant monitoring (leaf area etc.). The climate computer controlling the greenhouse made it possible to record and assess different sets of data such as outer and inner temperature, insolation, CO_2 level etc.
The overall conclusion is that, beside the variety, environmental conditions dominantly influence the amount of lycopene even in case of soilless cultivation. Although these environmental factors can, in certain extent, be adjusted in greenhouses, plants react in a sensitive way to changes occurring in light conditions, temperature and CO_2 level.

Keywords: hydroponics, tomato, temperature, insolation, artificial regulation of carbon dioxide, content value, lycopene

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PRECÍZIÓS GÉPKEZELÉS SZEKCIÓ

IMPLEMENTING SECTION CONTROL SYSTEM FOR TRADITIONAL SEEDERS

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Introduction

The technical improvement of agriculture recently involves two main areas: reaching the required power by stronger power engines and the optimal utilisation of existing power by using IT tools. The constant technical developments have made it possible to provide stable power needed for hauling and operating the working equipment. Physical dimensions limit the growth of machinery; the highest possible power must be derived from the finite volume.Agricultural machines become more and more complex mechatronic systems. One of the most intense fields of development is the replacement of hydraulic power transmission. Electrical cables and powerful electric engines fulfil the necessary tasks instead of high pressure and cumbersome pipes.

Literature review

During the last decade information technology has been rapidly developedin the agriculture. Today the term precision agriculture (PA) covers all advanced technologies utilised in agricultural production. There are two fundamental technical pillars of PA:

- high accuracy geolocation(GNSS[1], RTK[2])
- computer systems of tractors and machinery can communicate on a standardised platform via an ISOBUS system.

The above-mentioned info-communication technologies provide the basis for precision machine operation. These precision methods mean location specific and specimen specific interventions in plant production and animal husbandry, respectively. One of the key solutions of precision machine operation resulting considerable savings is section control. In case of implementing section control the working range is divided into sections. The tractor controls the operation of the machinery by taking already cultivated areas and parcel boundaries into account. For example, in a given operating situation of asix-row seeder the system does not switch all the six rows off, but only that one or two rows that become needless. In this way overlaps can be avoided, but seeds will be delivered to all utilisable areas. For completing these tasks high accuracy geolocation (in Hungary it means an accuracy of 2.5 centimetres) and machinery applied with ISOBUS system.

One hindrance to developing technology is the acquisition of necessary machinery. The cost of machines equipped with such advanced info-communication systems is high. There may be compatibility issues among the different machines. Generally agricultural holdings with an area larger that 300 hectares have the financial conditions for implementing such investments. Moreover, the parcels of smaller farms are often tiny and irregular. In these lands overlaps between sessions are much more frequent, especially when cultivating sides and the last row. In case of small parcels these situations arise in greater number than during large-scale production.

In our research covering the area of precision machining we examined how an outdated machine could be retrofitted with an ISOBUS network and in which way could this system be attached to an advanced tractor having micro-controller network. The aim was to create a complete unit suitable for implementing precision arable farming operations.

Materials and methods

The John Deere 6R Series tractor used for section control has everything that is needed for this task (i.e. RTK and ISOBUS). Section control is provided by installing the John Deere Rate Controller 2000. The tractor accesses this controller via the ISOBUS connection. Sections of the traditional seeder can be electronically controlled. The Rate Controller performs the task of switching sections on and off according to the commands received through the ISOBUS. The tractor is able to identify the seeder and recognises its parameters (i.e. type, number of sections, physical dimensions).

Figure 1 ISOBUS connection

Figure 1 shows the ISOBUS connection of the tractor (right side) to which the "smartened up" machine can be connected. The controlling computers of the tractor and the seeder maintain direct data flow via this connection. Based on the exact geographical coordinates the controller of the tractor can send commands on switching the sections on or off. The current installation of Rate Controller 2000 makes unidirectional information flow possible: the tractor sends commands to the machine.

Figure 2 shows the display of the tractor's virtual terminal. The controller identifies the parameters of the machine that are shared through the ISOBUS connection. It can be seen that the JDRC2000 controller can deal with six sections – six rows. The number of seeds to be sown is also indicated. In its current state the controller cannot adjust this value. The data is included for the documentation.

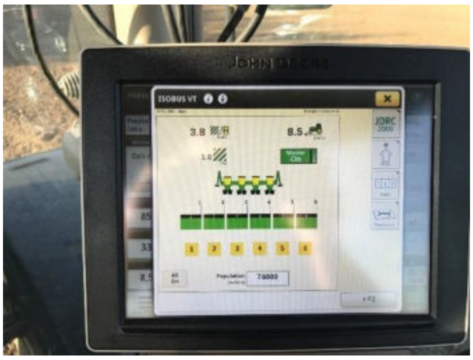

*Figure 2*The seeding machine as seen on the Virtual Terminal

The controller shall be connected to the ISOBUS network. ISOBUS is a type of CAN network: beside the feed line it includes two signal lines and the grounding. The controller shall be connected to the sections one by one. In this article we used a six-row seeder, although the controller can manage more than six sections. This controller can only switch the sections on or off; the amount of seeds cannot be adjusted. Section control can be implemented for several workflow processes (e.g. administering chemicals during sowing).

Figure 3 shows the connector of Rate Controller that includes both the signal cables heading toward to the ISOBUS connector and the controlling outputs of the sections.Connections were established based on the documentation of Rate Controller and on the implemented measures.

Figure 3 Rate Controller connector

After establishing the connection the tractor identifies the machine and its sections. The tractor can, via the ISOBUS connector, control the sections by using the preset cultivation data. As a result overlaps and the amount of input material is decreased.

Results and assessment

Without applying section control the six-row seeder used, in each case, more seeds thanthe product of the area and the number of seeds would have justified. The increased amount of seeds did not result higher yield. Avoiding overlaps requires extra labour input so that plants can have ideal area for their development. Under section control exactly the necessary amount of seeds can be sown calculated by the area and the number of seeds. Input material is saved by using this method. Without section control seeds are sown in surplus that leads to denser plant cover. If all these plants were left in the field they would compete each other for nutrients, thus less yield will be available by using more seeds. Removing the redundant plants requires extra labour, therefore it leads to increased workforce and energy consumption – beside the larger use of input material.

Figure 4 Rate Controller in working

Figure 4 shows how section control is implemented in practice. The tractor and the machine can be seen in the middle of the picture. The pink line indicates the preset parcel boundaries. The blue area is where the machine has already been to. It is obvious where overlaps occur on row level. In case a whole row would be overlapped, the controller switches it off. At the bottom of the screen it can be read that the tractor is currently using the following systems:

- documentation
- automatic steering
- automatic turning
- section control

Another great advantage of precision agriculture, beside control section, is the ability of changing the amount of seeds sown. Based ona preset covering map section control always administer the amount assigned to the certain coordinates. Redundant rows are switched off according to the completed work (covered areas) and the boundaries. A covering map is also needed for implementing varied intensity sowing. The tractor possesses this ability, however the seeder is currently not able to perform this feature. Such machinery would be needed for which the amount of sown seeds ran be electronically regulated. The number of seeds is indicated, but it serves only documentation purposes. The preset number of seeds will be recorded for the completed work, although it is not necessarily the same as the number set for the seeder.

Summary

By using the control system described in this article traditional seeders can be engaged in precision farming. The same quantity and quality of products can be achieved by decreaseduse of labour and input material in case of applying section control.

Figure 5 Result of section control

Keywords: ISOBUS, Rate Controller, section control

Acknowledgement

This publication has been completed within the framework of project no. EFOP-3.6.1-16-2016-00016 focusing on training and research profiles with intelligent specializations on the Szarvas Campus of St Istvan University involving agricultural water management, hydroponic plant systems, alternative crop production related to improving precision machinery in agriculture.

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Abstract

This article introduces a method to improve a traditional seeding machine capability to work by an ISOBUS system section control.Utilisation of the experimental seeder can improve the effectiveness of the plant production and can make this precision technology more economic.

Keywords: ISOBUS, Rate Controller, section control

ESTABLISHING ISOBUS NETWORK ON A TRADITIONAL TRACTOR WITH THE PURPOSE OF CONTROLLING PRECISION MACHINERY

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Introduction

Precision machine operation is involved in several fields of agriculture. It is fundamentally built on intelligent electronic and software solutions. In case of mobile machinery applied in agriculture it can be observed regarding both automotive machines and towed machinery.

Installing sensors and controllers on traditional machinery in order to operate it as an intelligent piece of equipment is a difficult task. On the other hand, numerous producers offer solutions for retrofitting traditional tractors with intelligent controlling systems. These are, in some extent, compatible with each other by providing ISOBUS conformity. By using these retrofitted systems such an automotive machine can be created that is able to control intelligent agricultural machinery.

In this article we discuss the systems suitable for controlling a precision machine and describe the structure and function of a selected system.

Problem definition

In case of developments related to the ISOBUS system a reference network shall be established to which the self-developed equipment can be connected for testing their functions.

At the early phase of the development a network with suitable parameters can be built even in a laboratory environment. However, in case of testing prototypes under realistic conditions field examinations and measurements are necessary; therefore, it is recommended to install the reference network in an automotive machine.

High-priced machines equipped with an ISOBUS system are obviously eligible for testing the performance of such prototypes, but these are not always available and the warranty does not cover this kind of utilisation.

Lower valued tractors can also be retrofitted with the ISOBUS system; producers offer different solutions for achieving this result. Hardware elements of these retrofit ISOBUS systems are joined to the original system of the tractor by only a few connection points, unlike the above-mentioned high-priced machines into which the ISOBUS is being integrated together with other systems.

Clearly distinguishable hardware elements of retrofitted systems provide the possibility of implementing such modifications during the test phase that can minimise the potential damaging of machines caused by the failure of tested equipment. For example, an emergency stop device can be built in so that the entire ISOBUS system could be disconnected by the push of a button.

Based on the above considerations we decided to acquire a retrofit ISOBUS system. Among the major producers Ag Leader, ANEDO, Kverneland, Müller Elektronik, Reichhardt and Topcon offer this kind of solutions.
After comparing the systems available on the market we chose the ANEDO open: system providing basic ISOBUS functions. This system has been installed on our Claas Ares 576 ATZ tractor.

Materials and method

Hereby we introduce and describe the elements of the system as well as their functions and structure. First of all we give an overview of the wire harness representing the backbone of the entire system as well as the hardware elements responsible for power supply and electricity (Figure 1).

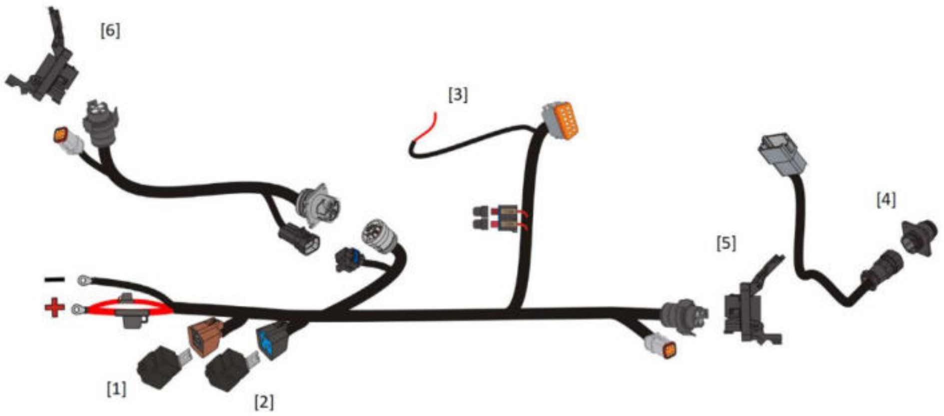

Figure 1. ISOBUS connectors and wire harness

The system receives power directly from the battery; it includes a 12V 30/40A relay [1] for ECU power and a 12V 70A relay [2] for main power. These relays are connected to checkpoint 15 of the tractor[3] that can be found beyond the ignition switch, thus when the ignition of the vehicle is switched off, the power supply of the ISOBUS system is ceased, too.
The system has one in-cab [4] and two breakaway connectors. These are standard connections; the primary (rear) breakaway connector (implement bus breakaway connector, IBBC) [5] has an active terminator(terminating bias circuit, TBC), while the secondary (front) one [6] is a passive terminator.
The tractor does not have a 3 point hitch top link, therefore the IBBC connector and its wire harness have not been installed. An active terminating element (TBC) was connected instead.
The Tractor Electronic Control Unit (TECU), the Universal Terminal (UT) and other accessories (AUX) are connected to the system via the in-cab connector. The installed system includes an ANEDO open:panel T50i terminal and an ANEDO open:ISOBUS

box with switches (Figure 2). The minimal functionality of TECU is implemented by different components of the built-in terminal software.

Figure 2ANEDO open:panel T50i terminal and ANEDO open:ISOBUS box with switches

This terminal offers one CAN, two RS232, five signal (digital/analogue input), one video and one USB interface. Out of them the CAN interface is currently used for ISOBUS communication, the USB port is necessary for down- and uploading data using pendrives, while a Garmin GPS 19x HVS GPS device using NMEA 0183 protocol is connected to one of the serial ports. An inductive sensor is attached to a digital input in order to measure distance by detecting wheel revolution.
Based on the data provided the above-mentioned devices the TECU application run on the terminal sends the speed values measured by wheel revolution (Wheel-Based Vehicle Speed) and GPS data (Navigation-Based Vehicle Speed).
The software allows to add further components that, after connecting them to the remaining free interfaces, can provide new sets of data. For example, signallers from power take-off (PTO) and from the 3 point hitch can be connected engaging one analogue interface each. They can give information on the Rear PTO output shaft speed and Rear hitch position.
Other applications available on the terminal are related to different functions of the UT. The currently used licence contains the precision functions of parallel tracking (Figure 3), TC-BAS (Task-Controller Basic) and TC-GEO (Task-Controller Geo Based), but the

licence can be extended in order to reach other functions such as TC-SC (Task-Controller Section Control).

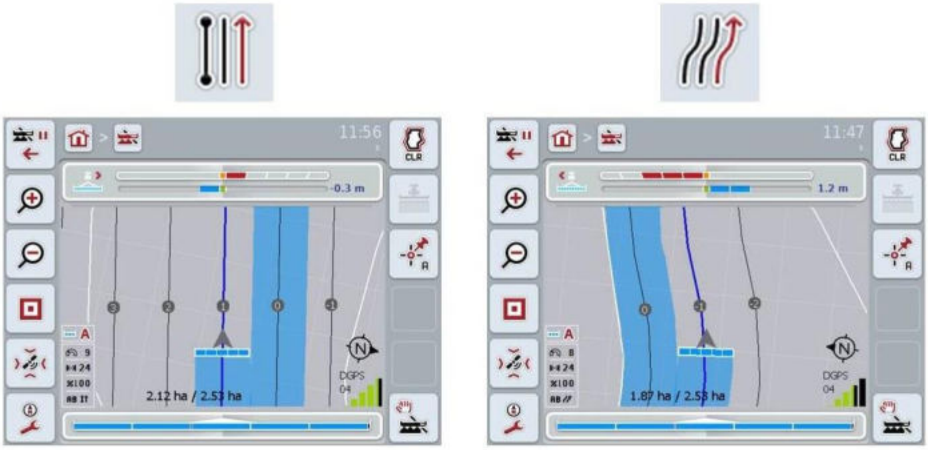

Figure 3Parallel Tracking straight and curve mode

The box with switches has additional switches and buttons that can be programmed to manage different functions of the connected machinery. For instance, section control can be implemented via this device. Furthermore, it plays an important role in testing self-developed tools and equipment, since AUX control is a very complex part of the ISOBUS protocol.

Summary

With the help of the installed system the tractor is able to control and handle precision machinery. Moreover, it can be used for field examinations and measures as well as for testing self-developed devices.
The standard connectors ensure the plug and play connection for all machinery using ISOBUS system. Applications run by the terminal fulfil different precision functions such as row alignment, creation of parcel maps or the recording of completed works assigned to each plot in the field.
The system can be developed and improved. New and useful data can enter the network by installing additional sensors. These data can be used by the machinery for performing their precision functions. The number of these functions can also be increased by installing new applications. For example, the automatic section control of sprayers, fertiliser distributors and seeders can be accomplished.

Keywords:precision machine operation, ISOBUS

Acknowledgement

This publication has been completed within the framework of project no. EFOP-3.6.1-16-2016-00016 focusing on training and research profiles with intelligent specializations on the Szarvas Campus of St Istvan University involving agricultural water management, hydroponic plant systems, alternative crop production related to improving precision machinery in agriculture.

Literature

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ANEDO Ltd. -open_panel T50i V0.3
ISO_11783-01_(General)
ISO_11783-02_(Physical_Layer)

Abstract

Installation of up-to-date sensors and controllers to an agricultural implement that is beginning to date is a quite complicated issue. Solving this kind of problem for an anachronistic tractor is simpler as a lot of complete controlling systems can be found on the market. These systems are compatible to each other and they are also ISOBUS conform. Adapting an adequate controlling system results a modern tractor that is able to operate a smart machine.

In this article we review some useable controlling systems that our experimental tractor could be equipped with and evaluate that we could utilise the precision functions.

Keywords: Precision agricultural machinery, controller network, ISOBUS

THE ROLE OF AGRICULTURAL V-BELT DRIVES IN PRECISION MACHINE MANAGEMENT

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Introduction

The application of V-belt drives in agricultural machinery and equipment is widespread due to their advantageous attributes. Relatively complex drive alignments can be created, large axle spacings reached. They can be applied in case of either parallel or diverting shafts. The establishment of the drive does not require complex structural elements. An adequately sized V-belt drive provides stable revolution and torque. Furthermore, it is a energy-transforming structure with low power loss. It also has advantageousproperties regarding flexibility and vibration absorption.We use standardised calculating methods as well as parameters determined by empiric experience and laboratory experiments during the designing and scaling of V-belt drives. These parameters are valid under properly aligned drives and normaloperating conditions.The service life of belt drives planned by using these methods and operated under extreme conditions typical in case of agricultural machinery is not appropriate; they do not provide clear and predictable information for maintenance planning. In this case we can count on the results of numerous endurance tests conducted under the certain operation conditions.
Agricultural harvesters are generally large plate-bodied and self-propelling structures in which the majority of machine units applied for adjusting the crops (i.e. treshing, cleaning, transporting etc.) are powered by V-belt drives. The distance between axles involved in the drive operation as well as the angular error can fluctuate in a wide range. The misalignment and angular error of pulleys can be caused by constructional instabilities or the deformation of the vehicle body due to operation. Although V-belt drives work sufficiently under these conditions, such errors have unfavourable effects on the life expectancy of belts and can lead to the decrease of efficiency. Thus, the above-mentioned alignment errors significantly influence the operational safety of the entire machinery.

Literature review

Like all machine structures, V-belt drives operate at a given efficiency that can be given as the quotient of the net and input power. The difference between the two value is the power loss, the majority of which is transformed into heat. During the power transmission of belt drives the temperature increase of the belts can generally be the result of two impacts (Gerbert, 1972, 1974). Macroscopic friction of connecting surfaces generates heat, while part of the hysteresis loss caused by the repeated use of the belt is also transformed into heat(Almeida and Greenberg, 1995).In case we measure the sustained operational temperature of the V-belt as loss intensity we can make conclusions regarding the efficiency of belt drives.

Beside drive parameters several other factors influence the connection between belts and pulleys as well as the slip (relative movements) such as the operational conditions, contaminated environment, temperature, relative humidity, drive misalignments etc. These macroscopic slips cause the wearing of the belts. The heat produced by friction influences steady power transmission and its efficiency.

The largest permissible deviation are determined by producers based on the diameter of the pulley. They do not take the nature of the error into consideration. The largest permissible deviation can be due to the parallel misalignment (see figure 4/a) or the angular error (figure 4/b). In both cases the straight belt sides suffer greater deviation and greater friction when contacting and leaving the pulleys. In case of parallel misalignment friction is increased in both sides of the belt. In case of angular error only one side is involved. In this latter situation a laden and an unladen side can be distinguished.

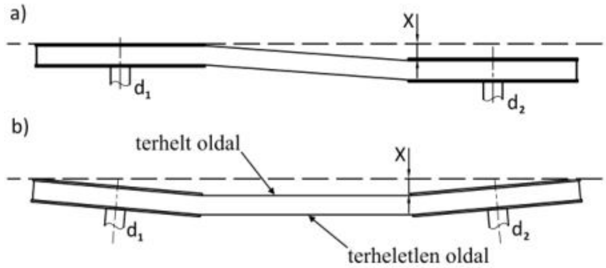

*Figure 1*V-belt drive alignments of a crop harvester

Materials and methods

The temperature of the V-belt is determined by the equilibrium of generated and given off heat. This state is influenced by several hardly controllable factors, such as air temperature and humidity, temperature and thermal capacity of contacting partsetc. We have considered these values constant during the experiments, since we implemented the measures under the same conditions in order to achieve comparable results. We select the temperature increase of V-belts as our examined parameter. It shows the power loss between the two equilibriums – i.e. the steady-state of standstill and operational temperatures.

During the experiments we examined the sides of pulley connected by grooves. We received temperature date followingthe processing of images taken by thermal cameras about the active surface of the V-belt.

Results and assessment

SPZ section V-belts were used for the experiments. Pulleys were aligned at the plane of the drive, within the permissible margin of tolerance, then set at a value one magnitude larger and later we doubled it. Relative alignments of the pulleys were created by parallel shifting and the angular error of axles.

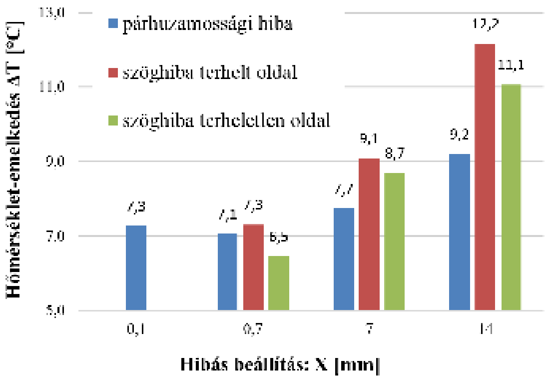

*Figure 2*Temperature increase of V-belt drives due to its geometrical misalignments
(profile: SPZ; d_1 = 150 mm; i = 1; L_d = 1207; f_0 =15 s^{-1}; M_1 = 8 Nm; F_H = 119 N)

As a result of pulley misalignments V-belt drives operate at higher temperature. It causes the deterioration of drive efficiency and decreases the lifetime of the V-belt. As it can be seen in Figure 2 not only the size but also the type of the misalignment influences the temperature increase of the V-belt. Angular error of pulleys causes the uneven warming of the belt sides. It is created by different frictions in the active sides of belts. More heat is generated on the laden side. On the other hand, temperature of the unladen side can be lower at the margin of tolerance than values within the margin of tolerance.

In case of settings within the margin of tolerance declared by the producers no significant difference can be observed in the temperature increase of V-belts. Exceeding the permissible margin of tolerance V-belts converge to different temperatures.

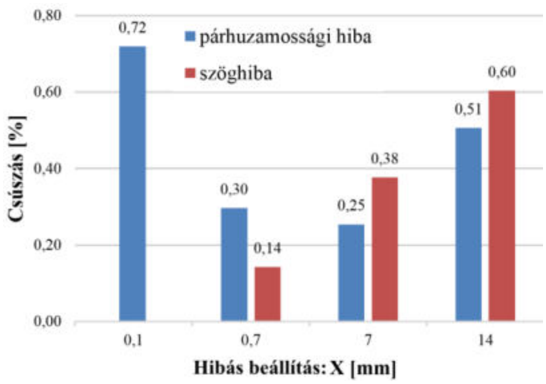

*Figure 3*Belt slip emerging due tothe geometrical misalignments of V-belt drives
(profile: SPZ; d_1 = 150 mm; i = 1; L_d = 1207; f_0 =15 s^{-1}; M_1 = 8 Nm; F_H = 119 N)

During the examination of power loss caused by the misalignments of belt drives we measured not only the temperature changes of tight side, but also the revolution differences of shafts. It is shown in Figure 3 depending on the setting of misalignment (X).In case of larger misalignments within the tolerance margins provided by producers the difference of revolutions is smaller. The load was the same during the different experimental settings, therefore the tangential belt slips must have been identical. The alignment errors triggered the differences observed in revolution. We assume that these variances were created by the change of effective radius in the entering zone of driving and driven pulleys. The misalignments led the belt toward larger or smaller radiuses. The larger modification (transmission) compensated the revolution decrease resulted by the slip.

Summary

We analysed the misalignments of pulleys via the experimental examination of loss composition regarding v-belt drives. We have set the temperature increase and slip of belts as assessed parameters. Fundamentally two impacts lead to performance loss: macroscopic friction of connecting surfaces and the hysteresis loss caused by the repeated use of the belt.

Increased friction plays an important part in the temperature increase of v-belts caused by the alignment error of pulleys. It leads to the decrease of efficiency and service life of drives. Therefore, the reliability of machinery largely depends on the alignment.

Keywords:precision machine management, v-belt drive, infraredthermal analysis

Acknowledgement:

This publication has been completed within the framework of project no. EFOP-3.6.1-16-2016-00016 focusing on training and research profiles with intelligent specializations on the Szarvas Campus of St Istvan University involving agricultural water management, hydroponic plant systems, alternative crop production related to improving precision machinery in agriculture.

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Abstract

The efficiency of V-belt drives is determined by several factors collectively: the slip occurring during drive transmission, the external friction occurring when the belt enters and exits the pulley as well as the hysteresis loss resulting from inner friction. Main objective of this paper is analysing the temperature conditions of V-belt by infrared thermal camera depending on various belt pulley parallel and angle misalignment. A certain V-belt cross section was analysed on a self-developed test equipment in various belt pulley parallel and angle misalignment. It was stated that the temperature increase of V-belt is influenced by the geometrical misalignment. In this study an experimental method was developed to define the V-belt temperature increase in function of belt pulley parallel and angle misalignment. On the bases of the test results optimal parameters can be calculated that serve as beneficial references for designing and tuning V-belt drives.

Keywords: precision machine management**,** V-belt, infrared thermal analysis, belt misalignment

INTEGRATED DEVELOPMENT OF PRECISION FARMING AND AGRICULTURAL INFORMATICS

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Introduction

Value-creating processes of enterprises are connected to human activities. These activities leading to results, products and impacts are initiated by human motivation and goals. People use tools and machines during production in order to achieve their objectives. General (ontological) system model of such activities includes the fundamental system components as well as the relationships and interactions among them. This general model can be seen in Figure 1.

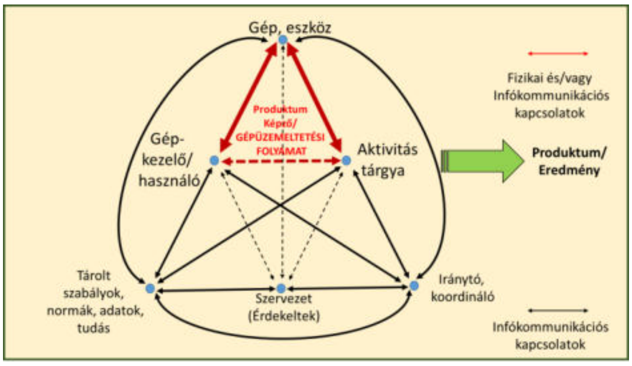

Figure. 1 System model of the human activity

Value-creating (producing) and value-maintaining processes (e.g. technical assistance) are realised by the three main components, i.e. people, machines and work objects. Interactions among them can be based on physical and/or info-communication connections. Further interactions indicated in this model relate to the organisational structure representing bidirectional communication of signals and information.

Literature review

Depending on local circumstances very diverse and numerous types of activity can be identified in agricultural enterprises. The general (ontological) system model of activities can, in great extent, facilitate the establishment of agricultural informatics systems adequately reflecting this complexity. Our agricultural production is mainly characterised by mechanised production. Machines represent one of the keyand most dynamically changing resources of farming. Mechanised technological processes are elementary components of creating or maintaining value. From a general point of view any type of machines can participate in two kinds of processes during their lifecycle.

One of these processes occurs when people use machinery in accordance with its essential functions. A general characteristic of this machine-utilisation process is that people, by exploiting the function of the machine (tool), make expedient changes on the object of the work. During these utilisation processes the structural state of the machine has been changed. Reaching a determined level these changes generate some kind of correctional or reparational work –summarised by the term technical assistance process. In this case the machine itself becomes the work object.

Enterprises use several machines for implementing their activities.Designing and coordinating the processes requires control regarding both types of processes. The operational system of machines contains the processes of operation and technical assistance as well as the control of them. At higher level control is necessary regarding the entire system operation. Communication tools facilitate efficient cooperation. General model of the machine operating system determines important conceptual structure and general terminology context. It serves designing and planning functions, control and IT developments (Figure 2).

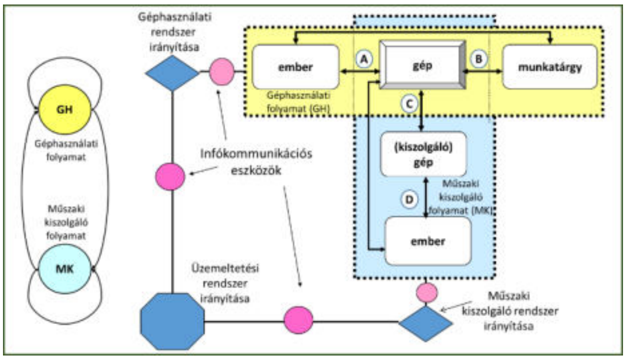

*Figure2*General model of machine operating systems

Both the static and operation-related dynamic data of the machine operating system shall provide an essential part of the IT system.In the above figure ‘A’ indicates the connection between human and machine. Numerous info-communication processes can be related to itthat are summarised by Figure 3 and the list below it. This example tries to give an idea of the increasing importance of interactive solutions in IT regarding the currently available technical and technological possibilities.

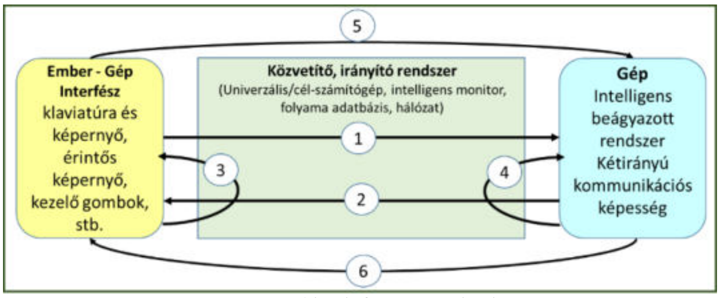

Figure 3 Human-Machine info-communication processes

1. The human sends a command or message to the machine.
2. The human receives a message about the different states of the machine/process.
3. The human asks and receives information from the machine.
4. The machine/process asks and receives information from the computer.
5. The human/operator directly intervenes to the process.
6. The human/operator directly observes the state of the machine/process.

IT-related attributes can also be attached to the relation indicated by 'B' between the machine and the work object. Intelligent sensing and signal processing solutions built in advanced machines can provide users with such data that were previously inaccessible. For example, some precision sowing machines have signal recording devices which not only control the continuity of the sowing process, but also able to give information at the end of the work session on the unevenness of the planting distance by using the form of a histogram.

Materials and methods

It is possible to establish connection between the histogram created by the embedded intelligence of the sowing machinery and the yield curve of the corn variety sown (Figure 4).

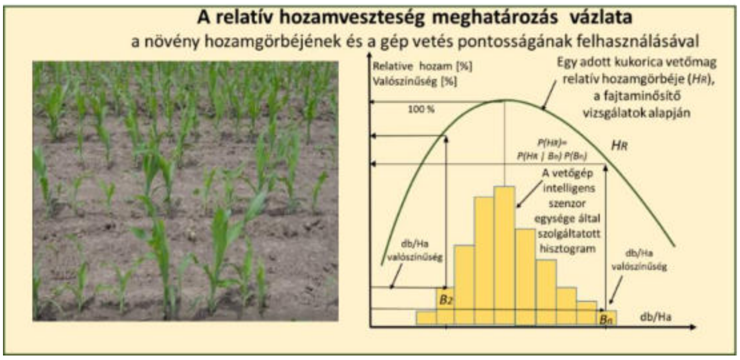

*Figure 4*Draft of determining relative yield loss

Using the legend of the figure and applying the context of the total probability theorem a new piece of knowledge, i.e. the relative yield loss caused by the uneven planting distance can be calculated.

$$P(H_R)=\sum_{i=1}^{n} P(H_R \mid B_n)\, P(B_n)$$

Important information technology attributes can be connected to relations indicated by 'C' and 'D' regarding the general model of machine operating systems (Figure 2). One of the fundamental functions of technical diagnostics is to provide information for users on the currentmechanical conditions of the examined machinery. This task can be completed by the cooperation of hardware and software systems and networks at different level. An example of this process is shown in Figure 5.

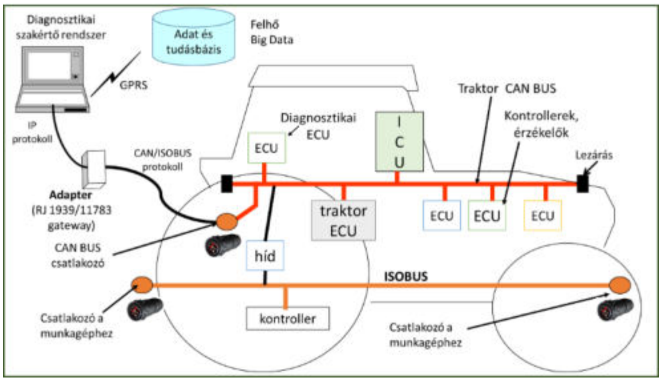

*Figure 5*Network cooperation of systems implementing technical diagnostics in a tractor

Device network of the examined machine (CAN BUS, ISOBUS) connects, via a standard network gateway, to the computer running the diagnostics software and the expert system. The computer may use wireless network in order to connect to the systems of the producer or the integrator and receive support if necessary. Examination results are transferred to the central system through this network enlarging the knowledge base and information available on the given type of machine. One of the most important preconditions regarding the effective operation of this system is the conflict-free cooperation of network system components, software and databases. This issue is solved by standardisation.

The control of machine usage processes is realised by the bidirectional flow of information. IT components of the system and their connections are introduced in Figure 6. Production controllers and coordinators send information to the person engaged by the implementation process. The information is based on the data available on machine operators, machines and work objects.

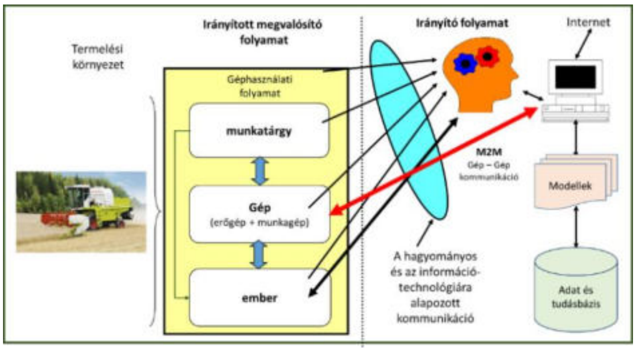

Figure 6 Elements of the machine usage process controll and their IT connections

Results and assessment

The Machine-to Machine (M2M) communication is a relatively new technological solution in the field of information flow and communication. Machines with embedded intelligence and the ability of communicating via external networks have triggered considerable advancements in system operation. Main features of the M2M technology are summarised in Figure 7. In case of mobile machinery the data communication service (GPRS) of cellular phone networks ensure the establishment of connections. M2M contributes, in large extent, to the more efficient management of machine operating systems.

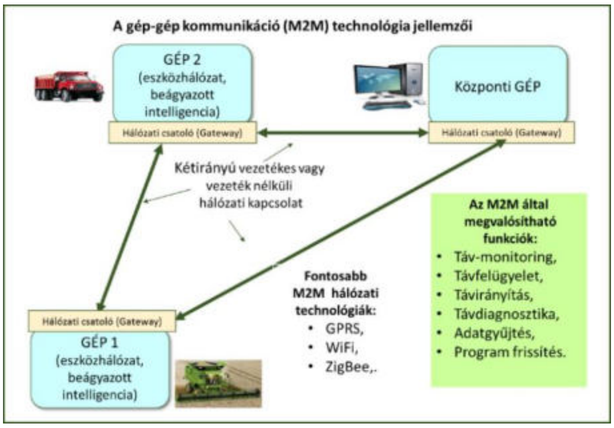

*Figure 7*Main features of machine-to-machine communication (M2M) technology

Acknowledgement

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Abstract

This article introduces the background of precision agriculture technological.It deals with those up-to-date info-communication technologies that determine the development of precision agriculture.

Keywords: precision agriculture, info-communication, BUS technologies