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**J. Olt, T. Kikas, L. Meneses (Editors)**

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# **I AGRICULTURAL ENGINEERING**

## Mechanical behaviour of selected bulk oilseeds under compression loading

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**Abstract.** Cold pressing or compressive mechanical expression of oil from bulk oilseeds without thermal treatments or appreciable thermal effects facilitates the preservation of quality in expressed oils and enhances their stability in storage. Mechanical response of bulk oilseeds during cold expression which are vital to equipment design vary with crops and are not completely understood. Mechanical behaviours of bulk seeds of camelina, pumpkin and sesame relevant to cold pressing were investigated at moisture contents of 7.04, 8.60 and 6.06% (d.b.), 80 mm pressing depth and a compressive force of 100 kN, applied uniformly at 10 mm min<sup>-1</sup>. Deformation varied with incremental force and among crops at peak compression. Deformations in Camelina, Sesame and Pumpkin seeds were 40.2, 41.6 and 50.9 mm at peak compression. Oil point pressures of Sesame, Camelina and Pumpkin seeds were 3.83, 7.49 and 8.83 MPa, respectively. Oil recovery at the applied load was similar in Camelina and Sesame but significantly lower in pumpkin seeds. Volume energy requirement for the expression of oil from camelina, pumpkin and sesame seeds were 2.56, 1.72 and 1.46 MJ m<sup>-3</sup>, respectively. An assessment of the pressed cake after oil expression revealed that the materials were capable of further deformation under compression.

**Key words:** oilseed, cold pressing, compressive stress, strain, energy.

**ACKNOWLEDGEMENTS.** This study has been supported by Integral Grant Agency of Faculty of Engineering, Czech University of Life Sciences Prague, grant number: 2016: 31130/ 1312/ 3106.

## Effects of different irrigation regimes on water use and vegetative growth parameters of walnut trees

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**Abstract.** The experiment was conducted during the growing season 2014 and 2015 to evaluating the water use and vegetative growth parameters of walnut trees under different irrigation water amounts. The irrigation water amounts applied based on a ratio of Class A pan evaporation as 50, 75 and 100 % under drip irrigation were investigated.

In the first year of the study all treatments when applying irrigation water to 8 times between 58.30 and 116.59 mm with irrigation application, the treatment in the second year and 15 times of 95.26 and 190.47 mm of irrigation water irrigation was applied. As a result of this study, the seasonal evapotranspiration in the treatments during the measurement period varied from 264.41 and 304.77 mm in 2014 and from 346.49 and 418.76 mm in 2015 depend on irrigation water applied.

The effects of the vegetative growth parameters of walnut trees of different irrigation practices were also examined. These values are based on the results of variance analysis; it concluded that the amount of irrigation water applied to the walnut trees vegetative growth parameters that not affect the results statistically.

**Key words:** Walnut, evapotranspiration, vegetative growth parameters

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## Web and android applications for district level nutrient management planning

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**Abstract.** Livestock manure, often perceived as a waste problem, is in fact a valuable nutrient source for plants. Besides, it does not only provide nutrients to plants, also improves soil structure, aeration properties and water retention capacity. A district level manure management study was conducted in Çanakkale/Turkey for developing a web based application for animal manure application rates. The procedure and the outcomes of the study were made available for better use of producers. Therefore, a web and an android based application was developed using java programming language coupled with android job package that accessed database for interaction and presentations of the results. The database was created with PHP scripting language to provide soil analysis results (electrical conductivity, pH, lime, organic matter, nitrogen, phosphorus, potassium, iron, manganese, copper and zinc) and manure application rates for major cultivars (paddy rice, maize, wheat, processing and table tomato) within the Gümüşçay district of Çanakkale and uploaded on a server. Then, a browser access interface to specific web page built up with Massachusetts Institute of Technology (MIT) app inventor 2 for android devices and published on official android market.

**Key words:** GIS, nutrient management, soil mapping, android application.

**ACKNOWLEDGEMENTS.** Special thanks to Gümüşçay Municipality for supporting this project. We would also like to thank Taşoluk Dam Irrigation Association for their assistance during the field work.

## Terrain surface monitoring with IMU equipped mobile robot

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**Abstract.** Stochastic processes are always changing. Measuring the process parameters never gives us a stable end value. In our institute we develop a statistical surface metrology method. To calculate the optimal length of measurement we use information entropy. The entropy is a saturating function. By exponential regression we are able to forecast the optimal length of measurement. Using the optimal measuring we are able to classify the terrain.

**Key words:** soil surface, terrain classification, inertial measurement unit (IMU), roughness, entropy, optimization, mobile robot.



## Classification of the soils formed in toposequence Kayı and Aydınpınar streams (Tekirdag) and classes of suitability to agricultural uses

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**Abstract.** The soils formed in the vicinity of Kayı and Aydınpınar streams were investigated in transects formed toposequence splitting vertically towards the coastal line of Thrace region. On the characteristic points of topography formed by the Kayı and Aydınpınar streams, five soil profiles were described, the two on the Oligocene marine deposits, the two on side stream creeks and the one on the alluvial bed representing low land. The morphological, physical and chemical properties of the samples taken from these profiles according to the genetic horizon principle were determined. The classification of these soils formed in the toposequence relationship and their suitability to various plants varieties were determined. The 4<sup>th</sup> profile in subgroup of Typic Xerofluvent were formed in alluvial land, The 2<sup>nd</sup> profile in subgroup of Calcic Haploxerept, 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> profiles in subgroup of Typic Haploxerept were classified.

The soil formed in a toposequence is different for suitability of plant cultivation varies. KA1, KA2 and KA5 soils are highly suitable for grass families expect maize and sudan grass while KA3 soil is medium suitable for grass families. KA1 and KA2 soils (expect soybean) are highly suitable, KA3 (expect alfalfa and sainfoin) and KA5 (expect alfalfa) soils are medium suitable and KA4 soil is marginal suitable for legume plants.

**Key words:** Soil genesis, toposequence, entisols, inceptisols.

## Investigation of the influence of the parameters of the experimental spiral potato heap separator on the quality of work

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**Abstract:** The known designs of potato heap cleaners have a series of disadvantages, particularly on sticky soils. In the newly developed and patented potato heap cleaner of a spiral type there is used the vibration effect and other technical solutions which ensure efficient self-cleaning of the rollers. Laboratory-field equipment was worked out and made for the investigations which had a spiral potato heap cleaner of a new design mounted on it. Under the field conditions the real technological process of digging and cleaning of the potato tubers from the soil admixtures was simulated in one row of the potato plantation. By using the developed methodology of a multi-factor experiment dependencies were obtained characterising the impact of the design and kinematic parameters of the cleaner itself upon the quality indicators of its operation (the soil separation efficiency, the cleanness of the heap, the damage and losses of the tubers), allowing optimisation of the design.

**Key words:** potatoes, harvesting, separator, spiral tool, multi-factor experiment.

## Effect of rake angle and cutting speed on energy demands of mulcher with vertical axis of rotation

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**Abstract.** The contribution deals with the reduction of agriculture energy demands. For maintenance and treatment of permanent grassland areas, areas left fallow and put to rest the mulching in combination with other workflows (mowing, grazing) is advantageous procedure. As conventional impact grass cutting and chopping is energy demanding procedure, it is proper to reduce the energy demands of such device. In the paper the effect of shape of cutting tool, particularly the rake angle, on energy demands of mulcher with vertical axis of rotation is studied. The effect of cutting speed on energy demands is also verified. The measurement was performed using mulcher MZ 6000 made by Bednar FMT Ltd. with working width of 6 m and three rotors. During the measurement the test rides using the cutting tools with different rake angle and cutting speeds of 105 m s<sup>-1</sup>, 89 m s<sup>-1</sup> and 79 m s<sup>-1</sup> were performed. The rake angle of cutting tools were chosen 0°, 15° and 25°. The test area was pasture with permanent grassland. During the measurement the torque and power, transferred through PTO to the machine, fuel consumption and GPS coordinates were measured. From each test ride the samples of grass matter were taken in order to determine the yield and moisture content. It was found that increase of the rake angle up to 25° and decrease of the cutting speed resulted in decrease of the power requirement of the mulcher.

**Key words:** mulcher, permanent grassland, energy demands, cutting tool, rake angle, cutting speed.

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## Influence of shape of cutting tool on pressure conditions in workspace of mulcher with vertical axis of rotation

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**Abstract.** Nowadays there is laid great insistence on work efficiency improvement. This effort also affects the construction of mowers such as mulchers. Mulching with a vertical axis of rotation is very energy demanding work operation mainly, due to high energy losses. These energy losses, but also the quality of work, are influenced by the airflow and associated conditions of pressure inside the workspace of mulcher. Airflow in the workspace ensures repetitious contact of the truncated forage crops with the cutting edge tool and thus ensures crushing of aboveground parts of plants. The paper deals with the influence of the cutting tool shape on the mulcher's inside workspace pressure conditions with the vertical axis of rotation. The influence of the trailing edge angle and rake angle on the pressure profile in the mulcher's workspace with dependence on the rotor speed was examined. Measurements were performed on a laboratory single rotor mulcher model. It was found that in the mulcher's workspace the vacuum is formed by virtue of the rotary movement of the cutting tools wherein the vacuum increases with rotor speed. The maximum measured vacuum was about 2.4 kPa and from the centre of the rotor towards its circumference almost linearly decreases. Furthermore, it was found that with decreasing trailing edge angle and with increasing rake angle the maximum vacuum decreases. When reducing the angle of the trailing edge from 45° to 25° led to reduction of vacuum of about 0.3 kPa (12.6%).

**Key words:** mulcher, pressure, airflow, cutting tool.

**ACKNOWLEDGEMENTS.** The paper was created with the grant support – 2016: 31190/1312/3116 – Effect of cutting tool shape on air flow in working area of mulcher with vertical axis of rotation. BEDNAR FMT, Ltd. for providing blade section of mulcher and help with the design of mulcher model.

## Comparison the field measurement crop evapotranspiration (ET<sub>c</sub>) and the estimated ET<sub>c</sub> using the methodologies of Dual K<sub>c</sub> in FAO -56 for the field tomatoes

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**Abstract.** The most known and used technique to estimate crop evapotranspiration (ET<sub>c</sub>) is the one based on the K<sub>c</sub> approach. Accurate estimations of crop water requirements and appropriate irrigation scheduling are required to enhance optimization and efficiency of applied water and sustainability for irrigated agriculture. The dual crop coefficient method (K<sub>cb</sub> + K<sub>e</sub>) is mainly used in irrigation scheduling for high-frequency water application such as tomatoes. Thus, the development of more precise and appropriate irrigation scheduling approaches will encourage water saving and sustainability of irrigation. The purpose of this study was to develop and calculate dual K<sub>c</sub> using the methodologies in FAO-56 for field tomatoes. In order to calculate dual K<sub>c</sub>, K<sub>cb</sub> and K<sub>e</sub>, all the climatological data between seedling and harvesting dates, the growth stages, soil water holding and water evaporation characteristics, soil and crop data required were input the computer program designed in the spreadsheet. The daily climatological data required and reference evapotranspiration calculated by Penman-Monteith equations were input the computer in order to calculate ET<sub>c</sub> depending on dual K<sub>c</sub>. For the all main and intermediate calculations were based on the guidelines in FAO-56. Thus, dual K<sub>c</sub>, i.e. K<sub>cb</sub> and K<sub>e</sub> were computed and plotted daily versus the crop stages. ET<sub>c</sub> predicted by using the daily dual K<sub>c</sub> calculated from FAO-56 guidelines was 623, 606 and 608 mm in the growing seasons of field tomatoes, 2003, 2004 and 2005, respectively. According to the field experimental results considering different irrigation scheduling treatments, crop ET<sub>c</sub> were ranged from 467 through 705 mm. Because amount irrigation water applied for the different irrigation treatments were ranged from 421 through 660 mm. In addition, it was discussed dual K<sub>c</sub> approaches and plotted vs. growing season. Dual K<sub>c</sub> values derived from FAO-56 might use when there were no enough experimental or precision results in study areas.

**Key words:** dual K<sub>c</sub> (K<sub>cb</sub>, K<sub>e</sub>), crop coefficient, FAO-56, evapotranspiration, tomatoes.

## Degradation of diclofenac and triclosan residues in sewage sludge compost

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**Abstract.** Land application of sewage sludge compost is an important and efficient tool in the remediation of industrial landscapes and agricultural soils in Estonia. A number of studies have shown that, as a rule, pharmaceuticals and personal care products (PPCPs) are neither completely removed by sewage treatment, nor completely degraded in the environment. In this study, degradation rates of diclofenac sodium (DFC) and triclosan (TCS) were determined during sewage sludge composting. Anaerobically digested and dewatered sewage sludge was mixed with sawdust at two different ratios (1:2 and 1:3 sludge/sawdust, v:v). Then aerobic composting was carried out. These ratios were chosen on the basis of previous studies on sewage sludge composting with different bulking agents. The initial concentration of DFC and TCS was 2 mg kg<sup>-1</sup> in relation to dry weight (dw). Low quantities of the studied pharmaceuticals were present in sewage sludge that was used for preparing the compost mixtures used in our experiments. The background concentrations of DFC and TCS were never equal to zero. The results showed that the difference between sewage sludge and bulking agent ratios (1:2 vs 1:3) in compost samples did not significantly affect temperature profiles during the experiment. The degradation of pharmaceuticals was more complete in the compost samples where the ratio of bulking agent was higher (1:3 by volume). The average degradation level (in all compost mixtures) was 95% for DFC and 68% for TCS. Pharmaceuticals entering into the soil may affect microbial activity, plant growth and development, and may have adverse effects on living organisms.

**Key words:** sewage sludge compost, sawdust, fertilizers, diclofenac, triclosan.

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## The next generation of multiple temperature sensor

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**Abstract.** Long-term and short-term measurements of temperature at different depths in soil have always been very complicated. The solution that was used until now was measuring using soil thermometers. Measurements were done at shallow depths and generally only allowed for measuring of one temperature, and always at the one depth which was determined for the measurement (normally 5, 10, 20, 50, 100, 150 and 300 cm). These problems were relatively limiting and impractical. It was therefore necessary to devise an alternative for a simple and effective solution that would eliminate these disadvantages – it was necessary for a probe to allow temperature to be measured at different depths at one measuring point without having to change its position. A requirement simultaneously arose for the need to be able to measure temperatures at greater depths, and a multiple probe was therefore conceived consisting of a rod for dynamic penetration tests.

**Key words:** temperature, measurement, penetration test, sensor, soil, thermometer.

## Experimental chamber dryer for drying hops at low temperatures

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**Abstract.** Hop drying takes a significant part in growers' costs of the final product processing. The current drying technology is based on drying at the drying air temperature of 55–60 °C for 6–9 hours to the final moisture content of about 10%. However, the process results in irreversible transformations and losses of, inter alia, heat labile substances contained in hops.

The experimental chamber dryer was tested at harvest in 2016. Assays hop drying were carried out at a temperature of the drying medium 40 °C. The research results in the form of an experimental new experimental chamber dryer will be used for testing of drying technologies at lower temperatures of the drying medium.

This is what will enable to preserve the quality of aroma as well as other characteristics of the components contained in hops.

**Key words:** hop, drying, chamber dryer, moisture.

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## Critical velocity of solid mineral fertilizers in a vertical upward airstream and repose angle

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**Abstract.** Critical velocity of mineral fertilizers in airstream is important not only at the application of fertilizers by spreaders but also at combine of fertilizing and sowing. The knowledge of angles of repose is important to design hoppers on spreaders for solid mineral fertilizers. Critical velocities for six solid mineral fertilizers were measured in the vertical aspiration duct of a laboratory sorting machine. Variation curves were constructed for particular fertilizers and the mean critical velocity of fertilizers (velocity of uplift) was computed. The mean critical velocity of fertilizers was between 8.53 and 12.43 m s<sup>-1</sup>. The lowest critical velocity was found out in the fertilizer UREA 46%, the highest in the fertilizer LAV. Statistical significance of differences in the critical velocity of fertilizers was assessed. Angles of repose of eight solid mineral fertilizers were also measured and statistical significance of differences was evaluated. The highest values of repose angle were determined for potassium salt and ammonium sulfate (35.9° respectively 34.9°), the lowest values for UREA and LAV (28.7° respectively 29.6°). The obtained results extend information applicable to an assessment of parameters of the operation quality of spreaders during mineral fertilizer application.

**Key words:** mineral fertilizers, variation curves, repose angle.

## Investigation of the parameters of a root crop crusher

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**Abstract.** Owing to the high specific bulk energy and crop capacity, good digestibility root crops are high-quality forage. Besides, when they are mixed with the rough fodder, the consumption of the entire prepared mixture by the animals increases, and the amount of the digested nutrients which are in the root crops may reach 90 %.

However, in order to attain that the nutrients were consumed by the animals more completely, it is necessary to make corresponding preparations for their feeding, including their crushing. One of the problems of the cutting process of the root crops is increased juice separation as a result of which significant losses of vitamins are observed. Therefore creation of crushers with rational design and technological parameters that would ensure the required quality of the ready-made product is an urgent task. The aim of the investigation set in this work was determination of the optimal inclination angle of the wall of the loading hopper depending on the size of the root crops and the projection length of the horizontal knife of the crusher.

As a result of calculations, theoretical dependencies have been obtained that allow to calculate the necessary inclination angle of the hopper wall depending on the thickness of the obtained slices and size of the roots to be crushed. At the estimated values the root crop will not roll over the cutting knife and compression will be minimal (consequently, a lesser amount of juice will separate, and the losses of nutrients will be minimal). An analytical expression has been obtained, and, on its basis, graphs built by means of which, depending on the sizes of the root crops to be crushed and the thickness of the cut slices, it is possible to determine the limiting value of the inclination angle of the hopper wall, considering the conditions of minimal juice separation. As a result of the conducted experiments, it has been found out that the cutting force decreases when the inclination angle of the hopper wall is increased, and it decreases 1.67...2.45 times when the inclination angle  $\alpha$  increases from 30 to 90°.

**Key words:** hopper, horizontal knife, minimal juice separation, compression of the root crop, crusher, inclination angle.

## **Modification of the rheological properties of honey in the honeycombs by the high frequency heating prior to honey extraction**

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**Abstract.** This paper addresses the issue of the extraction of highly viscous honey from the honeycombs. High viscosity can be caused by many factors. In the operational practice it is mainly about the difficult conditions (cold weather), post seasonal honey extraction or honey with naturally high viscosity (honeydew honeys). The objective was to design and validate a technology that will enable to reduce the viscosity of honey in the honeycombs by the high frequency heating and increase the effectiveness of honey extraction. The experimental part is based on the high frequency heating of honey, so called dielectric heating. In this process the heating of honey occurs evenly throughout the full volume of the honeycomb. To verify the proposed procedure, several groups of samples of the capped honeycombs were selected that contained honey of different botanical origin and rheological properties. For heating of the honeycombs, a high frequency chamber was prepared in the laboratory conditions. Honeycombs were placed into the chamber and heated to the desired temperature (from 15 °C to 45 °C). During extraction, the time dependence of honey extraction on the temperature of the pre-heated honeycombs was monitored. It was proved that the high frequency heating is suitable for the pre-processing of the honeycombs; heating is quick and reduces the viscosity. As a consequence of different permittivity of honey and beeswax, the strength of the comb is not changed when the electromagnetic field conditions are set properly, the honeycomb remains compact. Measurements demonstrated the time reduction of honey extraction based on the temperature.

**Key words:** honey, honey extraction, high frequency heating.

## PID control for sprayer sections under laboratory conditions

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**Abstract.** The objective of this study was to develop and test a PID controller to adjust the height of boom sections of sprayer booms. This study was conducted under laboratory conditions using an experimental frame representing the boom sections of the sprayer. The boom section was operated using an electro-hydraulic system driven by a hydraulic power pack. Ultrasonic distance sensors were used to adjust the height of the boom tips based on the set height values. During the on-off control, the sudden openings of the hydraulic valve conduits caused oscillations, resulting in unstable operation. In the PID control, increased gain up to 100% resulted in unstable operations and resembled the response of on-off control. With the use of low gain values, oil flow delivered to the hydraulic actuator was adjusted accurately using the proportional valves and smoother boom section motion was possible. The effects of different disturbances on the system dynamic responses were presented graphically using PID control.

**Key words:** field sprayer, active boom equalization, electro-hydraulic control, PID control.

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## Air quality mapping using an e-nose system in Northwestern Turkey

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**Abstract.** A gas sensor based electronic nose system is developed for monitoring air quality dispersion in and around livestock barns. The mobile system can be used in various applications under laboratory and field conditions. The system consists of 10 metal oxide Figaro gas sensors and a temperature/humidity sensor integrated with custom made circuits and data acquisition software. The sensors are sensitive to major odorous compounds. The e-nose system provides an easy, cost effective and user friendly tool for air quality monitoring. There is a relationship with sensor responses and gas concentrations are linear. Therefore, instead of calculating concentrations using statistical methods such as PCA and ANNs raw sensor data is used to monitor air quality. In order to monitor spatial distributions of sensor responses Kriging method is applied. Interpolation maps for each sensor response are developed. In order to visualize the areas where air quality problems occur, response of an air quality module is used as reference. Results showed the effectiveness of the developed system and method.

**Key words:** Gas sensors, electronic nose, environmental quality, livestock housing, air quality.

**ACKNOWLEDGEMENTS.** This work was supported by the 'Scientific and Technological Research Council of Turkey (TÜBİTAK)' under Grant No. 111O577.

## Land use/land cover change modelling of Ergene River Basin in western Turkey using CORINE land use/land cover data

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**Abstract.** Land use planning is a useful tool to find a balance among the competing and sometimes contradictory uses in order to achieve food security, economic growth, energy supply, nature conservation and other objectives. In this study, modelling land use/land cover change of Ergene River Basin in Western Turkey between the years of 1990 and 2012 was investigated. The CORINE land use/landcover data and ArcGIS software were used to detect land use/land cover change between the years, 1990–2000, 2000–2006 and 2006–2012. As a results, the artificial area (including settlement area and industrial zone) and water bodies increased by 39.4% and 47.9%, due to industrial development and new reservoirs construction, respectively, while wetlands and agricultural areas decreased by 1.1%, 1.0% and 32.1%, respectively. The change in the agricultural areas into industrial area corresponds to about 13,000 hectares, which is considered threatening not only natural resources but also food security since the basin has the most productive arable land of Turkey.

**Key words:** Land use/land cover change, CORINE, Ergene, Turkey.

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## Comparison of tillage systems in terms of water infiltration into the soil during the autumn season

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**Abstract.** The soil belongs to the most valuable parts of the planet Earth. It is, endangered by water erosion, which causes huge destruction every year, or damage to farmland. More than half of the agricultural land in the Czech Republic is threatened by water erosion. The measurement was performed in the location Nesperská Lhota. The trial has been established on loamy sand Cambisol. In the field experiment, there were created 6 different variants which varied by soil tillage and crop. In the individual variants maize and oats were located. The field trial has been existing for a long time, as it was founded in 2009. Two measuring methods of water infiltration were used for the measurements: a mini disk infiltrometer and a single ring. The measurement was performed in the period of September 2016 before the harvest of maize. The soil aggregates were already stabilized at that time after all tillage operations. The measurement result showed the difference between the methods of soil tillage. The greatest ability of infiltration had a variant of maize with inter-row oats. Surprisingly, it was followed by maize, which was processed by ploughing technology. The lowest infiltration capacity was showed by oats reduced by soil tillage. A variant without vegetation had the second lowest infiltration. Our results obtained at rate of water infiltration into the soil affirm the need to control measures in the late vegetative stages. It is important for most of the rainfall to be quickly infiltrated so that it prevents the formation of massive surface runoff.

**Key words:** mini disk infiltrometer; soil tillage; single Ring infiltrometer; water erosion.

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## Comparison of selected remote sensing sensors for crop yield variability estimation

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**Abstract.** Currently, spectral indices are very common tool how to describe various characteristics of vegetation. In fact, these are mathematical operations which are calculated using specific bands of electromagnetic spectrum. Nevertheless, remote sensing sensors can differ due to the variations in bandwidth of the particular spectral channels. Therefore, the main aim of this study is to compare selected sensors in terms of their capability to predict crop yield by NDVI utilization. The experiment was performed at two locations (Prague-Ruzyně and Vendolí) in the year 2015 for both locations and in 2007 for Prague-Ruzyně only, when winter barley or spring barley grew on the plots. The cloud-free satellite images were chosen and normalised difference vegetation indices (NDVI) were calculated for each image. Landsat satellite images with moderate spatial resolution (30 m per pixel) were chosen during the crop growth for selected years. The other data sources were commercial satellite images with very high spatial resolution – QuickBird (QB) (0.6 m per pixel) in 2007 and WorldView-2 (WV-2) (2 m per pixel) in 2015 for Prague-Ruzyně location; and SPOT-7 (6 m per pixel) satellite image in 2015 for Vendolí location. GreenSeeker handheld crop sensor (GS) was used for collecting NDVI data for both locations in 2015 only. NDVI calculated at each of images was compared with the yield data. The data sources were compared with each other at the same term of crop growth stage. The results showed that correlation between GS and yield was relatively weak at Ruzyně. Conversely, significant relation was found at Vendolí location. The satellite images showed stronger relation with yield than GS. Landsat satellite images had higher values of correlation coefficient (in 30 m spatial resolution) at Ruzyně in both selected years. However, at Vendolí location, SPOT-7 satellite image has significantly better results compared to Landsat image. It is necessary to do more research to define which sensor measurements are most useful for selected applications in agriculture management.

**Key words:** Remote sensing, crop yield, satellite images, Greenseeker, NDVI.

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## Evaluation of soil compaction caused by passages of farm tractor in a forest in southern Italy

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**Abstract.** In recent decades, the use of heavy machinery in forest management has significantly increased, causing the compaction, that often remains for many years and may contribute to a decline in long-term site productivity. Severity of the damage depends on vehicle mass, weight of the carried loads, ground morphology, and soil properties, such as moisture. In Southern Italy, timber extraction is mainly done by farm tractors and the study was carried out in a conifer stand to evaluate the changes in penetration resistance, the water content, the bulk density and the porosity, after different numbers passes 0 (control), 1, 5, 10 and 15 respectively, of one farm tractor (Landini – Landpower 135 TDI). The results indicated that all parameters were significantly higher in the trafficked soil portions rather than in the undisturbed ones. We can conclude that a significant relationship was observed between compaction degree and traffic intensity. In fact, the passage of forestry machines causes soil compaction, leading to significant changes in the soil structure and moisture conditions.

**Key words:** Forest Soil, Tractor Farm, Extraction, Machine traffic, Compaction.

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## Effect of drill machine operating speed on quality of sowing and biomass yield

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**Abstract.** The paper is focused on the study and evaluation of quality of the seeding of seeds and its effect on the biomass yield. The aim was to evaluate the space arrangement of the seeds by using of polygon method on one field with the repetition for different forward speeds of the drill machine. For the evaluation there were used digital photographs, which were taken during repeated measurements of the each value of the forward speed after sprouting of crop. These images have been used in order to determine the shape and size of the surface area belonging to the plant. Own software TtPolyM was used for the image analysis. The shape of the polygons belonging to the individual plants was expressed by values of the shape factor  $T_f$ . This factor characterises the suitability the shape of polygon surface related to the individual plant. By comparing of the values of the shape factors for different forward speeds of the drill machine we can determine the optimal value of the forward speed from the point of seed placement uniformity in horizontal level. During harvest of the crop there was analysed the variability of the biomass yield in relation to values of the forward speed used during seeding. The most suitable values of shape factor  $T_f$  (0.8519) was recorded for speed of drill machine set on 12 km h<sup>-1</sup>. For other tested speeds 8, 10, 15 km h<sup>-1</sup> were recorded lower values of shape factor 0.7994, 0.8173 and 0.8449, respectively. In determination of biomass production for drill machine speed 12 km h<sup>-1</sup> the greatest yield from 1 m<sup>2</sup> was observed. Subsequently, for speeds 8 and 10 km h<sup>-1</sup> was lower about 4.26% and 1.83%, respectively. For tested speeds of drill machinery 15 km h<sup>-1</sup> and above was observed only a small descent of yields about 0.6%. Fluctuation in yields affected by working speed then demonstrates fluctuation in sowing rate. It was also observed that the working speed of sowing machinery also affect the amount of yield directly. However, in case of lowest yield of straw recorded it was observed even 20% decrease in yield of grains.

**Key words:** drill machine, sowing quality, biomass, operating speed, yield.

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## Digital elevation models as predictors of yield: Comparison of an UAV and other elevation data sources

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**Abstract.** Topography usually plays an important role for yield variability assessment. This study provides insight into the use of surface models from different sources for agriculture purposes: unmanned aerial vehicle imagery, LiDAR data and elevation data acquired from a harvester. The dataset from an aerial vehicle was obtained in the form of ortho-mosaics and digital surface model using casual camera. The LiDAR data was provided by the State Administration of Land Surveying and Cadastre in the form of Digital Terrain Model of the 4<sup>th</sup> and 5<sup>th</sup> generation. The data of yield together with its coordinates were gained from a combine harvester in the form of a regular grid. Yield data was interpolated by kriging geostatistical method. Position data including an altitude was used for modelling the last digital surface model. All gained surface models were correlated with the spring barley yield. Results show correlation similarity across all tested models with the yield; no significant differences were sighted. Free available coarser scale data is able to predict a yield sufficiently. The study indicates less effectivity of using very detailed scale data sources due to its time-consumption or expensive data gathering and processing process.

**Key words:** Unmanned aerial vehicle, structure from motion, spatial resolution.

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## The influence of sloping land on soil particle translocation during secondary tillage

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**Abstract.** Tillage erosion causes the undesirable changes in the soil, mainly decreased of fertility and other functions of soil. The field experiment was aimed at measuring the influence of sloping field on the translocation of soil particles during seedbed preparation by Lemken Kompaktor seedbed combination. Sandy-loam Cambisol is on this field. Depth of soil tillage was 0.10 m, operating speed was 4.5 km h<sup>-1</sup>. To indicate the soil particles displacement limestone grit with the fraction size of 10–16 mm was used. The measurement results document that differences between movement of seedbed combination on the flat ground and upslope movement (angle of the slope 8.1°) are minimal in terms of displacement of soil particles. But the variant of downslope movement (angle of the slope 9.8°) showed statistically significantly higher values of translocation distances. The dependence of the translocation is in all cases described by an exponential function. The upslope movement of the machine for soil tillage cannot be understood as a full-value corrective measure to the incorrectly chosen direction of downslope movement.

**Key words:** tillage erosion, sloping lands, seedbed preparation.

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## Comparison of mechanical and electric drive of mulcher

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**Abstract.** The contribution is focused on comparison of mechanical and electric drive of mulcher with vertical axis of rotation by means of mathematical model. The mulcher has working width of 6 m and it is usually aggregated with tractor of minimal power of 150 kW. On the test plot the torque and power transferred through the tractor PTO, fuel consumption and the production of gaseous emissions components were monitored. This field measurement served as a basis for modelling as well as measured complete characteristics of the combustion engine of the tractor John Deere 7930. As a main base for the modelling the record of real operation of the tractor with mulcher was used. Then, in the software product MathCad the operation of the tractor with mechanical and electrical drive of the mulcher was modelled. In the case of the electrical drive of the mulcher the tractor with internal combustion engine, connected to generator was taken into consideration. Due to overall lower efficiency of the electrical drive with generator, worse values of the fuel consumption and emissions production in comparison with mechanical drive were reached in case of electric drive. At hypothetical use of batteries (100% electro-powered tractor) and when the energy mix at Czech Republic is taken into consideration, it is possible to reach the quarter values of emissions production in comparison with combustion engine.

**Key words:** Electric drive, emissions, fuel consumption, mulcher.

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## Field compaction capacity of agricultural tyres

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**Abstract.** The rating of soil compaction potential of agricultural tyres, in term Field Compaction Capacity (FCC index), is presented in the paper. Principal task of tyre FCC is used to predict a compaction risk of tyre under arbitrary combinations with inflation pressure and tyre load. FCC improves the originally used Compaction Capacity of tyre (tyre CC-rating) that expresses a compaction potential of single nominal tyre's contact footprint area for every catalogues load limits i.e. speed level under 10 km h<sup>-1</sup> and relevant inflation pressures exclusively. Primarily, FCC evaluation of tyre includes a calculation of standardized tyre footprint contact area. Adequate combinations of load limits and inflation pressure are used in a range of nominal tyre manufacture's dimensions ('catalogue size') according to ETRTO standards. The contact area size strictly depends on coefficient of tyre stiffness and sidewall deflection; both of them are a function of inflation pressure. Compaction effect of standardized contact area size is converted using compaction function in given contact pressure range. Databank of soil compaction functions for original CC evaluation is unchanged. The soil dry density limit in FCC conception corresponds with tyre CC approach since adequate (individual) mean contact pressure can be converted into compaction function i.e. the application of the same conversion rule for combination: actual versus standardized contact area size; actual versus nominal load, both for corresponding inflation pressure level. Critical soil dry density values for every soil type are set according to pedologic standards. FCC index offers a realistic prediction of the compaction level for any soil type under individual combination of tyre size, load and inflation pressure in depths 20, 30, 40 and 50 cm below a ground surface. It must be considered as the advantageous indicator of ecological tyre operations on cultivated crop-producing land.

**Key words:** field compaction capacity, agricultural tyres, contact pressure, contact area.

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## Reliability monitoring of grain harvester

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**Abstract.** This paper is focused on evaluation of operating reliability of grain harvesters. The aim of research is to improve the efficiency of combine harvesters by calculations which indicate a minimum annual performance and try to move in profit despite the high annual costs. Methods of paper containing all conditions of monitoring and evaluating of responsibility of grain harvesters. Those harvesters worked in real operating conditions. During three years of monitoring all important and other facilities and conditions of watching were recorded. After accumulation of information, their following working was set out according to the given literary sources and according to the own discretion based on experience during monitoring. The last part is focused on evaluating results and personal proposals how to make individual components work more effective. The most important results was recorded in case of turning point calculation where in years 2013, 2014 and 2015 at values 157.93, 156.19 and 166.86 ha year<sup>-1</sup>, respectively. However, real annual performance was recorded at values 760.5, 604.6 and 905.5 ha year<sup>-1</sup>. Thus, in all years of observation the grain harvester finished in profits.

**Key words:** harvester, reliability, performance, cost, turning point.

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## Theoretical analysis of the technological process of hop drying

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**Abstract.** This article is aimed at the current questions concerning hop drying, a process which represents a significant part of energy consumption for hop producers. The water content drops during hop cone drying from the original approx. 80% of moisture to 8 or 10%. The drying medium is heated air, and the maximum drying temperatures range between 55 °C and 60 °C, remaining practically stable for the entire duration of drying. Hops are exposed to these temperatures for 6 to 8 hours. The current old and ageing belt dryers record large losses. Their modernisation and particularly new drying technologies need to derive from perfect knowledge of thermal characteristics of materials and drying devices. The drying process and the actual implementation necessarily depend on the knowledge of the entire process calculation that is why the paper introduction outlines simplified issues concerning a ‘theoretical dryer’ following the h-x chart. An experimental measurement was carried out in an operating belt dryer. It included measurements of the drying medium thermal and moisture parameters and of the drying hop qualitative parameters. These drying parameters were monitored by means of continuously recording data loggers and of a laboratory analysis of the samples (hop moisture content, alpha bitter acids, Hop Storage Index). The drying process revealed that hops are practically dry ( $10 \pm 2.0\%$  of moisture content) already at the end of the second belt or possibly at the beginning of the third belt. It was also proven that hops are excessively dried (moisture content of 4 to 8%), adjusted to their final moisture of 8–10% through conditioning. Excessive drying results in considerable hop-cone shatter which makes the hop manipulation difficult during further processing, leading to larger losses of lupulin.

**Key words:** hop, hop drying, belt dryer.

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## Determining the dimensional characteristics of blueberries

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**Abstract.** The smoothly adjustable belt drums of belt sorters can be used in the processing of harvested blueberries. Previous tests with the smoothly-adjustable belt drums of belt sorters indicates the fact that further improvements are required to increase their sorting efficiency and uniformity. For this, the relationship between the dimensional characteristics of blueberries needs to be studied. The aim of this study is to determine connections between the dimensional characteristics of blueberries. To fulfil this aim, the length, diameter, mass, and volume are measured in an experimental group of blueberries. Based on these measuring results, mathematical equations are compiled in order to describe the connections between the dimensional characteristics of blueberries. The mathematical equations obtained are tested with a control group of blueberries. The results show that the volume of blueberries can most accurately be estimated by using a mathematical equation which takes into account the mass of blueberries. The mass of blueberries can most accurately be estimated with a mathematical equation which takes into account the diameter and length of the blueberries. Based on the results obtained, we can conclude that blueberry dimensional characteristics are linked and that these links can be used for various purposes.

**Key words:** 3D reconstruction, belt, modeling, shape description, sorters, volume measuring.

**ACKNOWLEDGEMENTS.** The research was financially supported by the internal research project of the Institute of Technology at the Estonian University of Life Sciences: 8-2/TI13002TEDT.

## Solution for automated bee colony weight monitoring

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**Abstract.** Future of the traditional beekeeping is to implement Precision Beekeeping approach and implement different automated and smart apiary monitoring systems for remote and optimised bee colony management. Behaviour of the bee colony can be monitored by the use of temperature, humidity, acoustic, video and weight systems. Each measurement system can give its own additional value for recognition of bee colony state. It is useful for the beekeeper to have at least one control colony with weight system equipped in the apiary. The hive scales is an important tool which gives assessment if food consumption has been high and whether there is a need for feeding. In most countries it is important to know how long the winter storage is, in addition it gives a very good indication of periods without any nectar flow. This paper presents conceptual design and prototype of honey bee colony weight monitoring system with GSM/GPRS external interface for packet-based communication with remote server. The central module with scales is placed on one of the hives and consists of temperature sensor, 4 strain gauge load cells for weighting purposes, RF and GSM/GPRS modules, photovoltaic cell array, battery, charge controller and minimal user interface for operational status signalling. The system allows sensor data logging to local storage and periodic data transfer to a remote server for further data analysis in different user applications. Data processing back-end component serves GET requests coming from remote measurement device, performs identification and raw data conversion using configuration stored in database.

**Key words:** precision apiculture (precision beekeeping), weight monitoring, smart apiary, internet of things.

## The impact of the termination technology of agro-ecological service crops on soil properties in open field vegetable production

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**Abstract.** The agro-ecological Service Crops (ASC) are introduced in the agro-ecosystems to provide or enhance ecological services, thus promoting the whole soil-plant system equilibrium. To avoid competition with the subsequent cash crops, the growth of the interposed ASC is terminated in advance of the cash crop planting. The traditional, most widespread, technique used to terminate the ASC is incorporation as green manure into the soil by tillage. However, since tillage includes energy and labour consuming and soil disturbing operations, the use of no/reduced tillage techniques (as the roller crimping technology) has received increasing interest.

A international research consortium (SOILVEG) including Estonian Crop Research Institute, was established in 2015 with the aim to study among others the impact of ASC termination on soil dry bulk density (BD), water content, soil structure and microbiological activity. Data are collected from Estonian trials in 2016.

The bulk density, gravimetric water content and structure of soil from 0–10, 10–20, 20–30 and 30–40 cm layers were evaluated. Plots with ASC *Secale cereale* L. (Winter rye) and *Lolium multiflorum* Lam. (Italian ryegrass) tend to have a better ratio of agronomical preferred soil particles. At the same time the increase of soil BD in all soil layers of plots with Winter rye under the roller crimping technology was perceived.

Microbial activity was estimated by determination of enzyme dehydrogenase in 0–20 cm soil layer. There were no statistically relevant differences in soil dehydrogenase activity (DHA) between the roller crimping and chop/plough treatments, at the same time DHA was higher in soils under the ASC cultivation compared to the soil without ASC crop ( $p < 0.05$ ). The soil DHA correlated with the C:N ratio of applied green manure ( $P < 0.05$ ).

**Key words:** agro-ecological Service Crops (ASC), roller crimping, soil bulk density, soil gravimetric water content, soil structure, soil dehydrogenase activity

**ACKNOWLEDGEMENTS.** This study has been carried out in the frame of the SoilVeg research project “Improving soil conservation and resource use in organic cropping systems for vegetable production through introduction and management of Agro-ecological Service Crops” and funded in the frame of the Core Organic Plus ERA-NET.

## Effect of altitude and vacuum pressure on flow rate of vacuum pumps on milking machines driven by gasoline engine and a generator

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**Abstract.** The objective of this study was to compare the performances of two vacuum pumps driven by an internal combustion (gasoline) engine (Vacuum Pump 1) and a generator powered electrical motor (Vacuum Pump 2) under different altitude and vacuum pressures. The vacuum pumps delivering a flow rate of  $350 \text{ l min}^{-1}$  at 50 kPa vacuum pressure were tested, which are commonly used in bucket type milking machines. Atmospheric pressures, maximum vacuum pump pressures, and air flow rates at milking pressures (38–50 kPa) were measured at altitudes from 0 to 2,000 m with 200 m increments. Maximum pump pressure reduced by 3.8, 11.3, and 19.9% for Vacuum Pump 1 at altitudes of 400, 1,200, and 2,000 m, respectively whereas Vacuum Pump 2 had 4.4, 12.3, and 20.4% less maximum pressure at the same altitudes. Air flow rate ( $457.7 \text{ l min}^{-1}$ ) of Vacuum Pump 1 at the sea level at 38 kPa working pressure reduced by 22.7% at the altitude of 2,000 m. The air flow rate reduced more (28.1%) at the operating pressure of 50 kPa for Vacuum Pump 1 at 2,000 m, compared to the sea level. Similarly, for Vacuum Pump 2, the measured flow rate at 38 kPa showed 19.1% reduction at 2,000 m while at 50 kPa the air flow rate reduced 26.4%, corresponding to  $352.3 \text{ l min}^{-1}$ . Differences in the air flow rates of vacuum pumps 1 and 2 under different vacuum pressures were insignificant ( $P > 0.05$ ). However, the effect of altitude and vacuum pressure on measured air flow rates was significant for each pump at 5% level. The regression equations were also obtained for atmospheric pressure-altitude, maximum pump pressure-altitude, air flow rate-altitude, and air flow rate-pump vacuum-altitude. High determination coefficients that were found for these relationships suggest that pressure setting can be accurately done as the altitude at which milking needs to be changed without suffering from air flow rate during milking with bucket type machines.

**Key words:** Milking machine, vacuum pump, gasoline engine, generator, altitude, pump pressure, air flow rate.

**ACKNOWLEDGEMENTS.** The authors would like to thank to Tarimak Company for providing the vacuum pumps, transportation, and technical support during this study.

## Influence of tied ridging technology on the rate of surface runoff and erosion in potato cultivation

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**Abstract.** Water management and securing good condition of soil is becoming an important factor in agriculture one of the reasons being adaptation to the increasingly frequent extremes in weather. Tied ridging technology enables to reduce significantly the loss of water and soil from arable land. The effect of a tied ridger mounted on 2-row planter and effect of 6-row tied ridger on basin renewal was tested in potato cultivation on plots of land with length of 10 m. During entire season lasting 135 days the technology helped achieve 78% of efficiency in reduction of surface water runoff and 88% of efficiency in case of soil loss. In the case of furrows with only tied ridging the water retained represented additional 15% of total water from rainfall (37.5 mm of 250 mm) over untreated furrows. In the case of basins formed in furrows with wheel trails the water retained represented 15% of total water from rainfalls in the trail. This water retained on the land would have otherwise flown off and would not have been utilized without this technology. The renewal of dams after 1/3 of the season increased significantly the efficiency of this technology. The technology of tied ridging significantly contributes to sustainable agriculture management.

**Key words:** furrow damming, basin tillage, soil protection, water runoff, trail.

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## Effects of Irrigation water salinity on evapotranspiration and spinach (*Spinacia oleracea* L. Matador) plant parameters in Greenhouse Indoor and Outdoor Conditions

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**Abstract.** Response of spinach to irrigation water salinity under greenhouse indoor and outdoor conditions was investigated in this study to reveal different weather conditions on salinity tolerance of the plant. For this purpose, saline waters at six different salinities (0.65, 2.0, 3.0, 4.0, 5.0 and 7.0 dS.m<sup>-1</sup>) were applied to spinach (*Spinacia oleracea* L. Matador) grown in pots. Soil salinity increased linearly with increasing salinity of irrigation water. Threshold salinity is 2.35 dS.m<sup>-1</sup> and yield lost slope after this threshold is 3.51% for indoor and threshold salinity is 2.83 dS.m<sup>-1</sup> and yield lost slope is 3.3% for outdoor. Salinity harmful effect on spinach yield is higher for indoor conditions than for outdoor conditions because of higher indoor temperatures. These results apparently showed that spinach salinity response could change with changing weather conditions especially for temperature. Yield response factors (ky), which is the ratio of relative evapotranspiration decrease to relative yield decrease, were close in the cases of irrigation water salinity in greenhouse outdoor and indoor (ky= 2.4 and 2.1), respectively. Considerable water consumption decreases because of salinity were determined. Every 1 dS.m<sup>-1</sup> increment in soil salinity caused about 1.35% water consumption decrease for spinach. Therefore, depressing effect of salinity on water consumption should be considered in irrigation and salinity management to prevent excess saline water application and to protect environment.

**Key words:** Irrigation water salinity, Spinach, Plant water consumption, Plant growth parameters.

## Different Soil Tillage and Shoot Length Effects on Vegetative Growth, Water Stress and Yield in cv. Cabernet Sauvignon (*Vitis vinifera* L.)

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**Abstract.** The study was conducted between 2010 and 2012 years in Tekirdag Viticultural Research Institute in Cabernet Sauvignon grape variety grafted on Kober 5BB rootstock. In the region conditions winter and spring months have been pluvial and rain in this period has caused to fast vegetative growth between bud burst and bloom of grape varieties. The aim of the study was to determine suitable soil tillage method, effects of different soil tillage and shoot length on vegetative growth and water stress level of Cabernet Sauvignon grape variety while suppressing vegetative growth. For suppressing vegetative growth 3 different soil tillage methods (conservation tillage, minimum tillage and conventional tillage) were applied. According to results of different soil tillage methods, the lowest pruning weight ( $1.58 \text{ kg vine}^{-1}$ ), leaf area ( $142.38 \text{ cm}^2$ ) and yield ( $3.2 \text{ kg vine}^{-1}$ ) were found in conservation tillage application. As to results of different shoot length, the lowest pruning weight ( $1.69 \text{ kg vine}^{-1}$ ) was obtained in 1.0 m shoot length application. As a result, in Cabernet Sauvignon variety, conservation soil tillage can advise in addition to conventional soil tillage in Tekirdag conditions because of its positive effects on leaf water potentials ( $\Psi_{\text{leaf}}$ ), yield, pruning weight and leaf size.

**Key words:** Cabernet sauvignon, abiotic stress, leaf area, conservation tillage.

## Comparison of constant and adjustable drawbar for a domestic horticulture tractor

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**Abstract.** In this study, adoption study of drawbar pull from constant height to adjustable height was investigated for improving mechanical structure, increasing efficiency of fuel consumption, decreasing slippage of domestic horticulture tractors. Materials were a horticulture tractor, an orchard sprayer, speed measurement sensor, load cell and fuel consumption. New drawbar which connection height of implements can be adjustable was designed and manufactured for horticulture tractor. Constant height drawbar and adjustable height drawbar were compared for pulling force, forward speed and fuel consumption by using orchard sprayer. Tests were carried out for 2 km, 1 hour, 3<sup>rd</sup> gear at 2500 rpm of engine. Forward speed was determined as 15 km/h for drawbar pull test and fuel consumption tests. According to the fuel consumption results; the adjustable drawbar was better than constant drawbar 0.29 l/h on soil and 0.34 l/h on concrete surface. Forward speed with adjustable drawbar was faster than constant drawbar as 1.7 km/h for field and 2.0 km/h for concrete surface. Drawbar pull of the adjustable drawbar was less than constant drawbar 36.58 N on concrete road and 74.29 N in soil surface even there wasn't any problem for pulling sprayer. Work was performed with less drawbar pull and less fuel consumption. Adjustable drawbar suggested to manufacturer for investigated horticultural tractor because of its advantages due to constant drawbar.

**Key words:** adjustable drawbar, orchard tractor, drawbar force, fuel consumption, forward speed

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## **II AGRICULTURAL ECONOMICS**

## The assessment of hazelnut mechanical harvesting productivity

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**Abstract.** Hazelnut cultivation represents a new opportunity for Calabrian mountainous and sloping areas (Southern Italy), where no alternative fruit crops, except forestry, could be settled. In this Region, hazelnut production doubled during the last fifty years, inciting the farmers to introduce mechanization in cropping practices such as harvesting in order to increase productivity and decrease production costs. Indeed, harvesting is currently one of the most expensive processes of the productive cycle, moreover to be time consuming if carried out manually. Mechanization degree depends significantly on the terrain topography: in sloping areas, rakes are often associated to aspirating machines to harvest the fallen fruit, while the employment of harvesting machines from the ground prevails in flat areas. In this context, the present paper aims to assess technical and economic aspects of harvesting operation, using a harvester from the ground model 'Jolly 2800' (GF s.r.l., Italy). Particularly, for technical purposes data about operational working time as well as working productivity were collected according to CIOSTA requirements, in two harvesting sites, whereas, for mechanical harvesting economic evaluation, an estimation model was applied to calculate machinery cost per hour. Moreover, the cost per kg of hazelnut in shell and the average cost per hectare were estimated also. The obtained results show a working productivity of 0.065 ha h<sup>-1</sup> op-1 in the first harvesting site, while it was equal to 0.022 ha h<sup>-1</sup> op-1 in the second one. Concerning the average cost per hectare, the second harvesting site showed the worst economic performances, with 550.76 € ha<sup>-1</sup> against 182.54 € ha<sup>-1</sup> obtained in the first one.

**Key words:** hazelnut, mechanical harvesting, tractor-mounted harvester, work productivity, economic analysis, sloping terrain.

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## Regulatives for biorefineries

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**Abstract.** The relationship between uncertainty and risk-taking behaviour towards innovations and Common Market protection are investigated in this article. Therefore, the aim of this article is to assess points of control over market regulation protecting innovative products. It was found that risk of creative destruction due to implementation of innovations is increased by regulators due to antimonopoly metric they use. EU fiscal policy implementation in renewable fuels in Czech Republic of both EU and CZ calculations is compared. Historical data has shown that regulators have collapsed market of high condensed biofuels. Pattern of fine calculation has explained a market collapse. Comparison of excise duty of favoured biofuels was compared with subsidies for photovoltaics. Substitution of former fossil fuels taking into account excise duty and subsidies of alternative or renewable energies is less market distorting than recent tariffs of excise duty and fines to first generation biofuels.

**Key words:** biofuel, biodiesel, diesel, excise duty, tax policy.

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## Entrepreneurial knowledge and skills of engineering and technology graduates

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**Abstract.** At the European Union level, it is recognised that new enterprises and more supportive environment for entrepreneurship is crucial for achieving economic growth, and entrepreneurship competence is one the key competencies necessary for success in a knowledge based society. Several Flash Eurobarometer studies on entrepreneurial intentions have previously shown that Estonians in comparison with most of the European countries' nations are considerably less willing to become entrepreneurs. So the development of entrepreneurship education in all levels of education system has started to receive more and more attention in Estonia. The present paper focuses on the entrepreneurial potential of the engineering and technology graduates from the Estonian University of Life Sciences. The aim of paper was to study their entrepreneurial activities and their opinions about critical knowledge and skills necessary for entrepreneurship. The analysis is based on a questionnaire survey of alumni entrepreneurship conducted in 2016 as a part of a programme "Edu Tegu- Development of entrepreneurial education throughout all educational levels". The focus is on the alumni of the Institute of Technology. The share of entrepreneurs among the engineering and technology alumni was 35,6%. The most frequently mentioned entrepreneurship subjects that should be included to the curricula were enterprise management, starting an enterprise, entrepreneurial finance, marketing and business planning, and knowledge on personnel management, law and contracting, risk and project management and product development. Respondents suggested introducing more entrepreneurship courses into the curricula in order to provide the graduates with skills in entrepreneurship.

**Key words:** Entrepreneurship competencies, entrepreneurship education, technology education, alumni

**ACKNOWLEDGEMENTS.** The alumni entrepreneurship survey carried out by Estonian University of Life-Sciences was part of the program "Edu Tegu- Development of entrepreneurial education throughout all educational levels" that is co-funded by the European Social Fund of the European Union.

## Risk Analysis Regarding a Minimum Annual Utilization of Combine Harvesters in Agricultural Companies

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**Abstract:** This article presents the results of entrepreneurial risk analysis concerning a minimum annual utilization of harvesters in a company providing agricultural services which a group of combine harvesters is used. Furthermore, this article presents the following analysed key operating parameters with the greatest influence on reaching the minimum annual utilization and performance: the changing market price of mechanized work, the volatile purchase price of the machines and the average maintenance costs.

Partial profit which an enterprise can reach through operating combine harvesters is directly affected by the level of their annual utilization. Not reaching the minimum annual utilization of combine harvesters would create losses that could result in termination of business activity in the specific field or even insolvency of the company. It is therefore necessary to monitor the key factors which influence the minimum annual usage and in case of negative developments to take timely corrective actions.

**Key words:** combine harvester, data modelling, key parameters, profit, business risk, agriculture, machinery utilization, business profitability

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## Some factors affecting the efficiency of potato production, under Al-Ghab plain conditions, Syrian Arab Republic

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**Abstract:** Data were collected by a field survey of 300 farmers from Al-Ghab region (Syria) during 2014–2015. The non-parametric Data Envelopment was used in analyzing the Technical efficiency. The relationship between farm size and production efficiency was considered. Technical efficiency amounted about 53% and most of farms are operating at low level of technical efficiency. The relationship between farm size and productivity efficiency is Non-linear, it decreases from small to medium farm size and then increases as the size increase. Large farms have the higher net farm income per thousand square meters and are the most efficient technically followed by small and medium farm size. To disclose that factors causing the technical efficiency, Two-limit Tobit Regression Model was used. The calculated results showed that, Household Size, Occupation, Farm Size, Experience in Farming, Seed Type and Membership are factors that cause the technical inefficiency potato farming at Al-Ghab region. Therefore, the Syrian Planning Board and Decision Makers should take this results into account when they draw their plans to improve farmer's skills by allocating more investment in farm research and extension programmers.

**Key words:** Potato, Technical inefficiency, farm size, Data Envelopment Analyses, Tobit Model.

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## Current Trends in the Development of Latvian Agricultural Holdings and GHG Emission Mitigation Possibilities

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**Abstract.** This paper aims to evaluate current development trends in the development of Latvian agricultural holdings in the context of greenhouse gas mitigation possibilities. The study results show that the current trends in the agriculture of Latvia point to two very different courses of development in farming: on the one hand, agricultural intensification may be observed, as the largest farms concentrate agricultural production, and productivity increases, which promotes the production of higher value-added agricultural products. On the other hand, 90% of the total agricultural holdings are still small, which are inefficient from the economic perspective; yet, their existence and operation are important in the context of regional development. The segment of these farms is the one that develops organic and non-traditional farming as well as contributes to rural tourism in Latvia. Since 2006, along with an increase in economic activity, greenhouse gas emissions from Latvia's agricultural sector have tended to increase. In this paper authors have discussed options how to reduce direct nitrous oxide emissions from the use of nitrogen fertilisers' through different GHG emission-reducing measures, like precision fertiliser application which is binding for intensive cereal farms; fertilisation planning and introduction of organic farming which are more binding for small farms.

**Key words:** agriculture, greenhouse gas emissions, Latvia.

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## Legumes in the diet of dairy cows from the economic perspective

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**Abstract.** Based on the experimental data, one can conclude that feed rations may comprise peas var. 'Bruno' and faba beans var. 'Lielplatone' grown in Latvia, thereby replacing the use of imported soybean cake. After summarising the results of trials, one can conclude that the diets comprising only one kind of legumes (peas or beans) were the most economically efficient, while the highest production efficiency was achieved if incorporating 22-24% 'Lielplatone' faba beans into the diet for dairy cows. In Europe and Latvia, foods of animal origin comprise, on average, 45% of the total agricultural output value; an essential role in the production of the foods is played by the supply of protein-rich feedstuffs to the livestock industry. An analysis of the factors influencing productivity in dairy farming shows that a diet is the most important factor that promote or hinder the functioning of the inherited genetic potential. In order to meet the dietary energy, protein and mineral requirements of cows, the cows have to be fed a diet according to their physiological condition. In recent years in many countries, research investigations into protein sources have been conducted, as a high protein content of feedstuff is the most expensive component of a feed ration. For this reason, their use in livestock diets might be economically inefficient and therefore the key focus has to be placed on opportunities to increase the content of protein in domestically produced feeds.

**Key words:** dairy feeding, legumes, economic assessment

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## Fair Trade and socially responsible production – whose duty? Estonian consumers' attitudes and beliefs

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**Abstract.** This article investigates how the Estonian consumers understand the Fair Trade (FT) idea and principles of social responsibility. The research objective focus on the consumers' attitudes and beliefs associated with FT and local Estonian agricultural production. Moreover, this study aims to examine is there any diversity in beliefs and attitudes towards supporting the local farmers and producers versus supporting the FT ideas. The respondents of the nation-wide sample (n=1007) evaluated the responsibility of the different economics agents, such as government, retailers, suppliers, producers, and consumers. By the opinion of most respondents the social responsibility means the giving the priority for the local Estonian agricultural production. The consumers tend rather not to believe that FT operates in the interests of workers and farmers in developing countries. The awareness and knowledge about FT ideas is not high. The authors suggest that in Estonian small market, both the local agricultural producers and FT farmers in the developing countries would need the similar approach and treatment from all stakeholders. That is, more protection and better trading conditions.

**Keywords:** Fair Trade (FT), social responsibility, consumer behaviour, attitude and beliefs, the local agricultural production.

**ACKNOWLEDGEMENTS.** The survey data utilized in this article has been commissioned by the non-profit organization Mondo.

## Knowledge Based Economic Growth Started to be a Rural Development Phenomenon in Latvia

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**Abstract.** Smart development is one of the most typical characteristics of knowledge-based economic growth in the national economy. The general aim of the project EKOSOC 5.2.3, in which the authors are involved, is to develop a socio-economic development strategy for rural areas for the 2020s. In Latvia, in a broader sense, the term “rural areas” is attributed to totally 110 municipalities that are parts of five statistical regions in the country. The direct aim of the present paper is to analyse development trends in the knowledge-based economic sector in the period 2009-2014 both in all the municipalities as a whole and in all the municipalities of each region and to form an understanding of the on-going processes, to draw conclusions and to make proposals for improving the situation. An analysis of LURSOFT, Central Statistical Bureau and survey data shows that the growth of the national economy’s knowledge-based segment in rural areas and an increase in the net turnover of enterprises operating in the rural areas were reported in the period 2009-2014. The knowledge-based economy enters the rural space at a quite fast pace, outpacing the processes taking place in the country’s largest cities, which allows asserting that at least a small decrease in disparities between rural and urban areas becomes evident. The problems in the rural space of all the regions involve the prevalence of the services segment and the low proportion of the manufacturing industry. The authors of the present paper come up with a number of proposals aimed at promoting a smart development process, which, first of all, involves the understanding of the nature of smart development that requires accepting a space as a system and recognising the interaction of processes taking place in the space.

## Evaluation of smart economy development in the RIGA planning region (LATVIA)

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**Abstract.** Aim of the study: to evaluate the indicators of smart economy development and the interaction with other indicators for the Riga planning region.

Methods: analysis of documentation and statistical data, the Analytic Hierarchy Process (AHP) method.

To evaluate the potential development of smart economy in the Riga planning region (henceforth – RPR), it is important to understand the present situation in the region, its specificity, and role in the context of provisional future trends. Two approaches have been employed in the present study to evaluate the situation on a regional level. One includes the collection and comparison of the basic economic development indicators, whereas AHP method has been used in the second approach, where 5 experts expressed their opinion on the options of potential development of smart specialisation in the RPR.

RPR as a capital city region is pronouncedly monocentric, with Riga city as its socioeconomic core that develops a wide network of functional ties, and creates a home for the part of the society that works in Riga, but lives in the adjacent suburban territories – Pierīga.

Traditionally the basic indicators of development include only the demographic and economic indicators. Sometimes these results are not objective, do not describe the potential for development, but clearly show the inequal social and economic situation in the region. To characterise the economic development in the RPR, we will include the economic profile data, statistical data and expert opinions on the population, regional government, state and EU influence on the development of the Pierīga region smart specialisation.

**Key words:** development of smart economy, smart specialisation.

**ACKNOWLEDGEMENTS.** Research supported from National Research programme EKOSOC-LV and Riga Planning Administration.



## Unified client service centres for rural development and smart governance in Latvia

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**Abstract.** Nowadays rapid increase of technological environment allows residents to be more mobile, choose working place, different from one's place of residence, start a new business or transfer company to rural areas, thus promoting polycentric development of a territory and increasing capacity of rural territories. It means that government should think of smart governance and service provision, providing different government services at one place. From June 2015 until December 2015, under the concept of improvement of public service system, the government of the Republic of Latvia established 75 unified state and local government customer service centres. Service centres operate on a local basis and in accordance with the uniform principles, provide customer with one place to access multiple public services. The objective of the present article is to evaluate the necessity and current activity of unified customer service centres and their contribution to smart governance of the country. The necessity for unified client service centres in the rural areas were therefore assessed with the analysis of attributable data, theory on establishment of such centres, and residents' survey, which showed that a big part of customers of the present centres are residents of neighbouring towns and cities where the regional governmental and local institutions are located, but they are attracted by the possibility to receive all the necessary services at one time.

**Key words:** unified service centres, smart governance, development, rural areas, etc.

**ACKNOWLEDGEMENTS.** The preparation of the paper was supported by the National Research Program 5.2. Economic Transformation, Smart Growth, Governance and Legal Framework for the State and Society for Sustainable Development-a New Approach to the Creation of a Sustainable Learning Community, Project EKOSOC\_LV.

## Results of fifteen-year monitoring of winter oilseed rape (*Brassica napus L.*) production in selected farm businesses of the Czech Republic from the viewpoint of technological and economic parameters

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**Abstract.** The paper presents field trials focused on technological and economic comparison of conventional tillage (CT) and reduced tillage (RT) technologies of soil cultivation and drilling of winter oilseed rape (*Brassica napus L.*). During fifteen production years starting in 2001/02, trials were set up in 520 fields of around 40 farm businesses located in all of the districts of the Czech Republic. With respect to average seed yields, no significant differences were proved with respect to tillage systems, to the application of organic fertilizers and to the fertilization during sowing. Irregular distribution of trial fields into the individual production areas influenced the outcomes though. Concerning winter rape seed yields, costs per production unit, and earnings per hectare, the most suitable production area proved still to be the potatoes one, but particularly over the recent period also beet production area. The corn production area produced, despite some exceptions, worst results. Over the fifteen-year time, the average oilseed rape yield of all 520 monitored fields was 3.72 t ha<sup>-1</sup>. Reduced tillage attained average yield of 3.73 t ha<sup>-1</sup>, i.e. matched almost exactly the one of 3.70 t ha<sup>-1</sup> attained by conventional tillage. Unit production costs realized by conventional tillage surpassed by 4.1% those gained by reduced tillage. Related earnings per hectare were on the other hand lower by 17.0%. With respect to fuel and labour consumption, reduced tillage brought significant savings reaching in average 20.2%, respectively 24.0%. In terms of yields, reduced tillage with deeper soil loosening proved repeatedly favourable results.

**Key words:** *Brassica napus L.*, tillage system, ploughing, costs, fuel consumption, labour consumption.

**ACKNOWLEDGEMENTS.** This work was partly supported by the research project of the Ministry of Education of the CR no. MSM 6046070905 and by the NAZV – project of MoA QH72257 ‘Valuation of agricultural land taking into account environmental protection’.

## The nexus between food insecurity and socioeconomic characteristics of rural households in Western Indonesia identified with Food and Nutrition Technical Assistance's approach by USAID

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**Abstract.** This study investigated correlation and regression analyses designed to assess the respective relationships between the Household Food Insecurity Access Scale/ Prevalence (HFIAS/ HFIAP) as a measure of food access, the Household Dietary Diversity Score, the Months of Adequate Household Food Provisioning (MAHFP) as a measure of food stability and (i) gender, (ii) education level, (iii) household income and (iv) agricultural strategies of households in North Sumatra province. Cross-sectional survey was conducted in Tobasa and Samosir Regency and its purpose was (1) to assess the food security status of rural households ( $N = 192$ ), (2) to identify the influence of selected factors on their food security condition and (3) to deliver outcomes which might play an important role in establishing appropriate policies and intervention strategy to prevent and reduce food insecurity. Due to the proven applicability in many studies, Food and Nutrition Technical Assistance's method was implemented for the comprehensive household food security analysis. The findings showed that 51.6% ( $n = 99$ ) households were considered as moderately or severely food insecure, 18.8% of the sample as mildly food insecure ( $n = 36$ ) and less than a third ( $n = 57$ ) of households was food secure. Further analysis investigated the correlation between household food security status and selected variables. The results highlighted the role of rural education, agriculture extension services, creation of employment opportunities and improved dietary diversity in reducing household food insecurity.

**Key words:** Food Insecurity, Food Access, Dietary Diversity, Indonesia.

**ACKNOWLEDGEMENT.** The study was financially supported by the Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, Project number 20165011.

## **III BIOENERGY**

## Research of solid biofuels from cotton waste biomass –alternative for Tajikistan’s energy sector development

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**Abstract.** An increasing awareness of the negative environmental cost associated with the combustion of fossil fuels and concerns over the geopolitical instability of the main oil producing regions is driving the development of renewable energy sources and biofuels. Use of solid biofuels made of different types of biomass became perspective alternative to conventional fuels in many countries. Such positive indicators as low cost of the final product that meets the quality of standards, not capital intensive production, possibility of producing briquettes/pellets from almost any agricultural waste or combination of raw materials are undoubted advantages of biomass based fuels. The main challenges for Tajikistan’s energy sector, which is depended on energy imports, are: to increase energy supply through better exploitation of hydropower and other renewable energy sources such as wind, solar and primary biofuels. Within the agricultural sector of Tajikistan, which is highly agrarian country, cotton accounts for 60% of agricultural output. According to the Ministry of Agriculture of Tajikistan 199,400 hectares of lands have been allocated to cotton cultivation in the year of 2014. Plenty of unused cotton stalks residual biomass could be effectively utilized for winter heating in rural areas. The main focus of the research was to investigate and assess physical, chemical and mechanical properties of pellets and briquettes produced from cotton waste biomass.

**Key words:** Cotton residues, biofuel, standards, pellets, briquettes, quality tests.

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## Reed canary grass cultivation's energy efficiency and fuel quality

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**Abstract.** The article discusses the energy yield and yield capacity of reed canary grass stands in semi-natural and cultivated meadows with edaphic conditions most favourable for species growing on fertile soil. Energy grass production yields have been assessed with respect to the issues of precipitation, sunshine, and frozen ground. In Estonia, a dried matter level of 4.2–8.5 t ha<sup>-1</sup> of reed canary grass may produce 72.91–147.56 GJ ha<sup>-1</sup> gross energy by using 1.48–3.06 GJ ha<sup>-1</sup> input energy, which consequently nets 71.44–1,445.00 GJ ha<sup>-1</sup>. The above finding indicates that 1 MJ input energy enables the production of 2.8 kg dry matter. The efficiency of energy production (ratio of energy returned on energy invested) depends on the amount of input energy used to grow and harvest reed canary grass. The input energy payback ratio for the given case was 48.2–49.4, which was higher than cases with lower and higher dry matter yield levels. Precipitation during the second part of the Estonian summer, heavy winter snow cover and a simultaneous frequent lack of frozen ground reduce the productivity of reed canary grass as energy hay because the winter or early spring harvest cannot be used.

**Key words:** bioenergy, energy payback ratio, fuel quality, harvest yield, *phalaris arundinacea*

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## Comparative study of oil palm fruit bunch processing in Nigeria

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**Abstract.** Fresh fruit bunch (FFB) wastes are generated from processing oil palm fruit bunch. The complexities of processing FFB limits the utilisation of the generated wastes especially empty fruit bunch (EFB), which may lead to loss of other by-products of FFB processing including crude palm oil (CPO), palm kernel (PK), mesocarp fibre (MF) and palm kernel shell (PKS). Three routes of FFB processing in Nigeria namely, industrial, small scale and traditional were compared by means of determining fruit losses associated with each processing route. Data on each processing route were collected in 2015 and 2016. Fruits left with EFB after FFB processing for each of the processing routes in 2015 and 2016 were weighed and quantified in terms of CPO, PK, MF, and PKS lost.

Results of the analysis showed CPO, PK, MF, and PKS loss with the industrial route are significantly higher than both the small scale and traditional ones. On an average 28.93 kg of CPO, 16.72 kg of PK, 74.59 kg of MF, and 26.54 kg of PKS were lost for every 1000 kg of FFB processed with the industrial route, whereas 0.0056 kg, 0.0032 kg, 0.014 kg, and 0.0051 kg were lost with small scale route, respectively. The smallest losses of 0.0034 kg of CPO, 0.002 kg of PK, 0.0087 kg of MF, and 0.0031 kg of PKS were obtained with the traditional route. In terms of energy, approximately 89 kWh and 31 kWh more energy were lost from MF and PKS, respectively, with the industrial route than the small scale and traditional routes. The economic analysis has shown that total of \$27 CPO lost per 1000 kg of FFB with the industrial system can offset the cost (\$19) of processing 1000 kg of FFB with the small scale system. Traditional processing route showed that more CPO, PK, MF, and PKS are recovered per FFB processed than in industrial route though no significant difference with small scale route was found.

The advantages of industrial route include high throughput and high quality CPO however, the losses associated with it makes it imperative to adopt a system capable of recovering up to 100% of the fruits during sterilization and stripping of fruits like the small scale and traditional routes and as well the generation of high bulk density and low moisture content EFB. A feedback system between the routes will ensure recovery of all the fruits and drying of EFB for use as fuel by the locals (small scale and traditional routes) who also supply FFB to industrial processors creating a closed loop system. The abundance of fuel due to availability of EFB will create an opportunity for independent power producers which can also be a spinoff of oil palm mills.

## **Agricultural vs forest biomass: production efficiency and future trends in Polish conditions**

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**Abstract.** Biomass is one of the main sources of renewable energy with rapidly growing trend in the European Union countries. The technical potential of biomass energy in Poland is one of the highest in Europe, estimated at approximately 900 PJ/year. Solid biomass is the primary Polish RES and the share in the structure of production in Poland amounted to almost 77% in 2015. The most common types of biomass are waste raw materials from crop fields and forests.

The paper presents current potential of the biomass of two basic types, i.e. agricultural and forest material, based on the analyses developed with the scenario forecast of future use in Poland. Detailed considerations include differences in efficiency of agricultural and forest biomass production. To develop the efficiency aspects some indices were proposed to compare potential of energy production basing on different kind of biological material.

**Key words:** solid biomass, renewable energy, energy efficiency.

## Tropical waste biomass potential for solid biofuels production

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**Abstract.** Subsequent utilization of waste biomass in developing countries occurs at poor level, despite the fact, that it has great potential in solid biofuel production. Densified waste biomass is utilized for direct combustion, therefore, its suitability (energy potential, chemical composition) must be determined in attempt to protect environment and reduce air pollution. Main aim of present research was to determine suitability of waste biomass originating from production of rice (*Oryza sativa*), Date fruit (*Phoenix dactylifera L.*) and Jatropha fruit (*Jatropha curcas*) for solid biofuel production. Within a moisture, ash and volatile matter contents, major chemical elements (C, H, N, O) and net calorific value (NCV) were determined. Rice waste analysis proved low NCV (14.33 MJ kg<sup>-1</sup>) and high ash content (20.74%), which presented problems during combustion. Jatropha fruit waste (cake) analyses exhibited outstanding NCV (24.44 MJ kg<sup>-1</sup>) caused by residual oil content. Within major elements analysis a low content of oxygen (26.61%) was proved (recommended). Date fruit waste exhibited average NCV (16.40 MJ kg<sup>-1</sup>). However, high oxygen content (44.01%) was defined as limiting factor. Overall evaluation proved greatest suitability for Jatropha fruit waste (cake), followed by Date fruit waste and lowest potential was determined for Rice waste. However, investigated plants are not cultivated for energy production purposes, thus, observed results achieved satisfactory level of their suitability for solid biofuel production.

**Key words:** briquettes, renewable energy, calorific value, *Jatropha curcas*, rice husk.

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## Utilization of waste biomass from post–harvest lines in the form of briquettes for energy production

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**Abstract.** A great amount of herbal waste biomass is produced nowadays during agriculture crop processing; also during ‘post–harvest lines’ operations. Such waste biomass occurs in the bulk form, thus, is not suitable for direct combustion; it can be improved by using of briquetting technology. Therefore, present paper provides chemical, mechanical and microscopic analyses of waste biomass originating from post–harvest lines and briquettes produced from it. Namely, waste biomass originated from production of oat (*Avena sativa*) – husks, wheat (*Triticum spp.*) – husks and poppy (*Papaver somniferum*) – straw and seed pods and mixture of all mentioned were investigated. Unprocessed materials were subjected to microscopic and chemical analysis and subsequently produced briquette samples were subjected to determination of its mechanical quality. A satisfactory level of moisture and ash content was observed, as well as, materials energy potential; oat – 17.39 MJ kg<sup>-1</sup>, wheat – 17.04 MJ kg<sup>-1</sup>, poppy – 14.48 MJ kg<sup>-1</sup>. Also microscopic analysis proved suitability of all feedstock materials within evaluation of geometrical shapes of their particles. However, evaluation of briquette mechanical quality unsatisfactory results. Process of briquetting revealed unsuitability of oat feedstock for briquette production; other materials proved following values of volume density and mechanical durability (in sequence): wheat – 1,023.19 kg m<sup>-3</sup>, 89.1%; poppy – 1,141.43 kg m<sup>-3</sup>, 94.7%; mixture – 972.49 kg m<sup>-3</sup>, 62.7%. In general, only poppy briquettes achieved requested mechanical quality level for commercial briquette production. However, undeniable advantage of investigated materials is the form they occurred in; no further feedstock preparation (drying, crushing) was needed.

**Key words:** solid biofuels, renewable energy, cereal husk, mechanical durability, calorific value.

**ACKNOWLEDGEMENTS.** The research was supported by Internal Grant Agency of the Faculty of Engineering, Czech University of Life Sciences Prague and further then by the Internal Grant Agency of the Czech University of Life Sciences Prague, grant number 20165003.

## Straw pellet combustion and emission characteristics evaluation on industrial 2MW pellet boiler

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**Abstract.** Straw and straw pellets are competitive renewable fuel sources and cheaper alternative than non-renewable fuels and some other types of biomass. However, there are certain problems in straw pellets combustion and heat utilisation processes. To better understand straw pellet combustion related difficulties, research on real life industrial 2MW pellet boiler application was conducted. This study presents boiler operational characteristics, composition of fuel, bottom ash and boiler deposits. Data confirms combustion temperature in furnace has direct impact on combustion quality and increased deposition rates on boiler surfaces. As analysed, the most common components in boiler fire tube deposits were alkali salts, while unusually high rates of sulphur compounds were found in bottom ash. Hypotheses on how these problems could be solved were made and further research fields offered.

**Key words:** straw pellets, biomass combustion, industrial boiler, emissions, deposits, agglomeration, sintering.

## **The economic sustainability of small-scale biogas plants in the Italian context: the case of the cover slab technology**

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**Abstract.** The growing interest on renewable energies, together with the public financial incentive systems established in several countries, has driven a fast innovation in the field of energy technologies, with the main objective to increase their sustainability.

This paper focuses on the production of biogas from agro-residues and animal manure; with particular attention to small-scale plants.

Based on a real case located in northern Italy, and taking into consideration the Italian public financial incentive system currently in force, the economic profitability of the cover slab technology is analysed, putting into evidence the main factors that affect it.

**Key words:** Anaerobic digestion, small-scale biogas plants, Italian biofuel plants.

## Physical properties of wastes from furniture industry for energy purposes

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**Abstract.** The aim of the study was to determine the physical properties such as moisture content, particle size distribution, density and calorific value of wastes from wood-based boards and to determine their suitability for energy purposes. The tested material included wastes from tooling fibreboards (MDF) and raw (PWP) and laminated (PWO) chipboards. Tests were conducted according to the standards. The materials from wastes after mechanical boards tooling were characterized by a similar low moisture content. The geometric mean of particle size values were 0.38 mm, 0.64 mm and 0.57 mm, respectively for MDF, PWO and PWP. The particle size distributions were right-hand skewed and non-aligned. It was found that the prevailing share had the smallest fraction and its largest share had wastes from MDF. Regarding to the high calorific value and low moisture content and high bulk density, it could be stated that the wastes from furniture industry are a good raw materials for energy purposes. These wastes can be combusted at proper conditions of this process.

**Key words:** wastes, furniture industry, fibreboards, chipboards.



## Suitability of oat bran for methane production

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**Abstract.** There is need to investigate the suitability of various cheaper biomasses for energy production. It is necessary to explore ways to improve the anaerobic fermentation process with the help of various catalysts. Biocatalyst Metaferm produced in Latvia previous studies with other biomass gave an increase in production. The purpose of study is evaluation of suitability of granular and crushed oat bran waste biomass for the production of methane and influence of catalyst Metaferm on anaerobic digestion (AD) process. The biomass anaerobic digestion process was investigated in 0.75 L digesters, operated in batch mode at temperature  $38 \pm 1.0$  °C. The average biogas yield per unit of dry organic matter added (DOM) from digestion of granular oat bran was  $0.400 \text{ L g}^{-1}_{\text{DOM}}$  and methane yield was  $0.193 \text{ L g}^{-1}_{\text{DOM}}$ . Average biogas yield from digestion of crushed oat bran was  $0.439 \text{ L g}^{-1}_{\text{DOM}}$  and specific methane yield was  $0.193 \text{ L L g}^{-1}_{\text{DOM}}$ . Adding of 1 mL Metaferm in substrates with not crushed or crushed oat bran increases specific methane yield by  $0.227 \text{ L g}^{-1}_{\text{DOM}}$  or  $0.236 \text{ L g}^{-1}_{\text{DOM}}$  respectively. Investigated oat bran can be used for methane production, but methane production was less than from traditional biomass, e.g. maize silage.

**Key words:** anaerobic digestion, oat bran, biogas, methane, additive Metaferm.

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## Biogas from wastes of pumpkin, marrow and apple

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**Abstract.** A lot of vegetables and fruits, which have been grown in Latvia or were imported from foreign countries, become waste, often due to unconformity to the marketing standards or biodegradation process fouling during storage. Waste biomass piles emissions during storage that contributes to global warming. It is appropriate to use such biomass as raw material for anaerobic digestion. This article shows the results of studies on evaluation of suitability of vegetable and fruit waste biomass for the production of biogas. Anaerobic digestion was investigated in 0.75 L digesters, operated in batch mode at a temperature of  $38 \pm 1.0$  °C. The average biogas yield per mass unit of dry organic matter added (DOM) from digestion of pumpkin biomass was  $1.095 \text{ L g}^{-1}_{\text{DOM}}$  and the specific methane yield was  $0.422 \text{ L g}^{-1}_{\text{DOM}}$ . Average biogas yield from digestion of marrow biomass was  $0.768 \text{ L g}^{-1}_{\text{DOM}}$  and the methane yield was  $0.274 \text{ L g}^{-1}_{\text{DOM}}$ . Average biogas yield from digestion of apple biomass was  $1.020 \text{ L g}^{-1}_{\text{DOM}}$  and the methane yield was  $0.451 \text{ L g}^{-1}_{\text{DOM}}$ . All investigated wastes can be a very good source for biogas production. Anaerobic digestion may be a solution to treat waste biomass from food production facilities or supermarkets.

**Key words:** anaerobic digestion, pumpkins, marrows, apple, biogas, methane.

**ACKNOWLEDGEMENTS.** This investigation has been supported by the Latvian National Research Programme LATENERGI.

## Biodiesel from tomato seed oil: transesterification and characterisation of chemical-physical properties

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**Abstract.** The transesterification process of an oil is influenced by four variables: reaction temperature, reaction time, amount of alcohol and amount of reaction catalyst. The cost of production, yield and chemical-physical characteristics are therefore directly dependent on these variables. In this work, tomato seed oil was transesterified and the influence of the quantities of the alcohol (methanol) and catalyst (potassium hydroxide) was tested. The values of total esters, density, kinematic viscosity, iodine value, acid number, linolenic acid, cetane number and residual glycerides in the different biodiesels produced (Bio from A to F), were studied and compared with the current European regulations EN14214: 2014 (Liquid petroleum products - Fatty acid methyl esters for use in diesel engines and heating applications - Requirements and test methods). The six obtained biodiesels yielded between 72.59 (BioB) and 96.8% (BioE) of the total esters. The presence of non-transesterified oil, besides being a yield index, also negatively affects the viscosity at 40 °C of the produced biodiesel. In fact, the only sample with a value within the legal limit was BioE (4.95 mm<sup>2</sup> s<sup>-1</sup>), while the others showed viscosity values higher than the 5.00 mm<sup>2</sup> s<sup>-1</sup> established by the European regulation. The density, however, always remained within the specified limits, with values between 880 kg m<sup>-3</sup> in BioE and 891 kg m<sup>-3</sup> in BioB. The presence of linolenic acid was well below the maximum legal limit in all samples, the iodine value ranged between 119 and 122 g I<sub>2</sub> 100g<sup>-1</sup>.

**Key words:** biodiesel yield, industrial waste, methanol, potassium hydroxide, tomato seed oil, transesterification.

**ACKNOWLEDGEMENTS.** This research was supported by the PON01 01397 fund: Agronomical, qualitative, technological, and marketing evaluation of traditional tomato product transfer (peeled, cherry, sun dried, 'piennolo') in innovative packaging for a market upgrading. Possibility of using industrial tomato waste (seeds and skins) for seed oil production as fuel and/or cosmetic applications and functional substances extraction. The authors have declared no conflict of interest.

## Evaluation of the inline stripping of ethanol during cyanobacteria cultivation in a bubble column bioreactor

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**Abstract.** Cyanobacteria are oxygenic phototrophic microorganisms capable of photosynthesis. In this redox reaction driven by light energy, carbon dioxide and water are converted into chemical energy in form of carbohydrates and oxygen. The output of this process is restricted by product inhibition from the bioethanol. Here, we evaluate a method of ethanol stripping in a bubble column for perspective use for determination of ethanol production rate of engineered cyanobacteria. The knowledge about the amount of condensation and recovery rate combined with HPLC measurement for ethanol determination can be used to specify the real amount of produced ethanol (absolute) by cyanobacteria in the used bioreactor. Stripping and recovery rate are depending on several parameter like flow rate, initial ethanol concentration, condensation temperature etc. Due to the high influence of these parameters they have to be supposed to be static regarding to the degrees of freedom.

To evaluate the system different ethanol concentration were tested for stripping and determination of recovery rate. As the stripping rate was much higher compared to the ethanol production rate with our *Synechococcus elongatus* PCC 7942 the medium was spiked with ethanol to varying concentrations of 0.5, 1 and 2% v/v. It could be shown that ethanol could be removed quantitatively. Removal rates of 97–98% were reached with initial ethanol concentrations of 5 g L<sup>-1</sup> to 20 g L<sup>-1</sup>. The results demonstrated determination of ethanol in the exhaust air stream and quantitatively recollection by cultivating engineered *Synechococcus elongatus* in bubble column bioreactors.

**Key words:** Bioethanol, stripping, inline down-streaming, cyanobacteria, bubble column bioreactor.

**ACKNOWLEDGEMENTS.** We thank Juliane Richter for her theoretical assistance. The project ALGENTICS AT-CZ 15 is financed within the scope of the European Union INTERREG Cooperation Programme AT-CZ 2014–2020, from the purse of the European Funds for Regional Development (EFRE).



## The use of maize stalks for energy purposes and emissions measurement during their combustion

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**Abstract.** Biomass is an ideal renewable energy with advantages of abundance resources and neutral in greenhouse gas circulation. Majority of this energy could have been used directly in agriculture itself. The rest of the biomass for other parts of industry or even communal parts could be made available as a refined and densified biomass available for direct combustion in form of bales. The objective of the work was a monitoring of possibilities of maize cortical use for energy purposes during combustion. Emissions measurement from the combustion of maize phytomass was performed by measuring device TESTO 350 M/XL. During the combustion of packages with the moisture of 18% and 38% was monitored and the effect of moisture on the content of gas emissions of CO, CO<sub>2</sub>, NO, NO<sub>2</sub> as well as the percentage of residual O<sub>2</sub> in the flue gas after combustion. All values of monitored emission limits were in current normative limits defined in Collection of Laws no. 356/2010. All emissions limits are in accordance to monitored standards for CO, CO<sub>2</sub>, NO, NO<sub>2</sub>, but on the other hand it should be noted that the more favourable results are based on combustion of cortical with moisture of 18% than at 38%. The issue of maize cortical harvesting considering machinery, technological and economical viewpoint within the Slovak republic but also worldwide is poorly understood and therefore these issues should be the subject of further research.

**Key words:** maize cortical, renewable energy, emission limits, maize cortical harvesting, maize cortical combustion.

## Wood ash – green energy production side product as fertilizer for vigorous forest plantations

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**Abstract.** Notable amounts of wood ash containing plant macro and micronutrient elements in balanced proportions are produced in Latvia. If bioenergy production source product is plant material, and facilities are operating well, then 'side product' fermentation residues or wood ashes should not contain elements in toxic concentrations. Wood ash contains P and K which are lacking in acidic organic soils and could work as fertiliser as well as a long term liming agent, besides that, all micronutrient elements necessary for physiological processes are present in wood ash. Wood ash could also be used as 'revitalization agents' – fertilisers to improve the growth of plantation forests. The aim of this research is to find and describe the positive effect of wood ash fertilisers on Norway spruce (*Picea abies*) and other economically valuable tree species. Research results show positive wood ash application effect on tree growth and vitality within the first 4 years when used for recultivation and revitalization purposes. Recycling of wood ash (0.5–3 t ha<sup>-1</sup> before planting) for fertilisation of and *Picea abies* forest plantations are a sustainable and effective solution for the improvement of tree growth as well as an environmentally safe method of utilization of bioenergy production residues.

**Key words:** wood ash, fertiliser, regeneration, recultivation, revitalization, soil amendment, Norway spruce.

**ACKNOWLEDGEMENTS.** The acknowledgements to the field team, and National research program No 2014.10-4/VPP-6/6 that have helped to achieve the goals of the research.

## Impact of clearfelling on dissolved nitrogen content in soil-, ground-, and surface waters: initial results from a study in Latvia

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**Abstract.** Conventional forest management has traditionally been targeted to enhance provisioning ecosystem services. Recently, however, awareness about the effect of forest management on other groups of ecosystem goods and services has been raised at the European and global levels. A number of initiatives addressing the evaluation and mitigation of the impact of forest management operations on biodiversity, soil quality, nutrient cycling, and water quality have been reported. In 2011, the development of a monitoring system to assess the impact of forest management on biodiversity and environment in the state forests of Latvia was initiated in the Latvian State Forest Research Institute 'Silava'. A number of studies to obtain experimental data and to test potential monitoring methods were implemented during this project. Among other activities, three research objects related to the quantification of changes in nutrient cycling after clearcut with whole-tree harvesting and stem-only harvesting were established. Data on changes in nutrient concentrations in soil solution, ground water, and surface waters, and on nutrient input through precipitation, are presently available for one year before and two years after clearfelling. Significant increase of dissolved nitrogen concentration in soil solution, as well as differences between stem-only and whole-tree harvested plots emerged only in the second year after harvesting. No significant increase of the dissolved N in the streams was observed, compared to the reference period. Ground vegetation recovery, amount of slash, soil properties and processes in the buffer zone are among those factors influencing the N leaching most, and these will be investigated further.

**Key words:** forest management, water, dissolved nitrogen content.

**ACKNOWLEDGEMENTS.** This study was conducted with the support of project Nr. L-KC-11-0004, 'Methods and Technologies to Increase the Capital Value of Forest', in collaboration with the *Forest Sector Competence Centre* and the Joint Stock Company *Latvian State Forests*. We gratefully acknowledge support from *Forest Research Station* in Kalsnava Forest district in performing forestry operations at the study sites and valuable advice and help from our colleagues at *Silava* – Roberts Matisons and Martins Lukins.

## Carbon stock changes in drained arable organic soils in Latvia: results of a pilot study

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**Abstract.** Drained arable organic soils in the most of European countries represent a minor part of the total area of farmlands, but these soils contribute significantly to national greenhouse gas budgets. The aim of the pilot study is to demonstrate methodology for determination of the changes of soil organic carbon stock after drainage of arable land on organic soil by evaluation of subsidence of the land surface from detailed historical pre-drainage topographic maps created during designing of drainage systems and LiDAR. Results of a pilot study show that ground surface level in arable land on organic soil has decreased by 0.8 cm annually after drainage, but soil organic carbon stock has decreased by  $4.2 \pm 3.3$  tonnes C ha<sup>-1</sup> yr<sup>-1</sup>. The results of a study show that pre-drainage topographic maps are suitable for estimation of organic layer subsidence after drainage. The estimated mean CO<sub>2</sub> emissions are about 47% less than the default emission factor for drained arable organic soils in boreal and temperate climate zone provided by Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories. The results substantiate the necessity to develop national methodology to estimate emissions from drained organic soils in cropland and grassland.

**Key words:** carbon stock, drained agricultural land, LiDAR, organic soil, subsidence.

**ACKNOWLEDGEMENTS.** The study was implemented within the scope of the research project 'Elaboration of methodological solutions and improvement of the reporting system of the GHG emissions and CO<sub>2</sub> removals from cropland and grassland', agreement No. 101115/S109.



## **Influence of raw material properties on the quality of solid biofuel and energy consumption in briquetting process**

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**Abstract.** The present paper is related to a pressing process research of raw materials with different density in order to investigate impact of biomass density on a formation of monolithic structure and the briquette's strength. Another focus of the study is an influence of raw materials particles' size on agglomeration process and quality of final product. Different biomass materials like two varieties of miscanthus, industrial hemp and apple wood were selected for experimental purposes of this research. Mechanical durability which represents one the main indicator of briquettes' mechanical quality (strength) was determined. The research was conducted using hydraulic piston briquetting press. For assessment of briquetting efficiency during the whole process energy consumption was measured. One of the most important factors that can affect briquetting process is the temperature of pressing chamber which was registered as well. The main goal of the research was practical study of possibilities for increasing production efficiency and quality of briquettes on hydraulic piston briquetting press with respect to optimization of particles' size of raw materials and use of raw materials the most appropriate density.

**Key words:** briquettes, bulk density, densification process, initial fraction, mechanical durability, piston press.

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## Biogas and hydrogen production from glycerol by *Enterobacter aerogenes* and anaerobic microbial communities

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**Abstract.** Biological hydrogen production by anaerobic fermentation of widely available renewable resources is a promising and advantageous area. Using microbiological hydrogen production from crude glycerol biodiesel-derived waste was utilized by obtaining renewable energy carrier. The purpose of this research was to study biogas and hydrogen production by *Enterobacter aerogenes* MSCL 758 and by natural microbial communities. Growth medium was supplemented with analytical grade, technical grade or crude glycerol. Inoculants from old municipal landfill, manure and lake sludge were also used. Biogas production was analyzed using Automatic Methane Potential Test System II. Part of the experiments were carried out in serum bottles and evolved gases were tested using mass-spectrometry. Fluorescence *in situ* hybridization was used for bacterial population dynamic determination. Optimal concentration for crude glycerol was found to be six grams per liter. Amount of hydrogen was significantly higher and amount of nitrogen gas was lower in case of analytical grade glycerol usage in comparison to crude glycerol fermentation. *E. aerogenes* acted in synergy with landfill substrate and manure in biogas production from technical grade and analytical grade glycerol. It was not the case for crude glycerol usage. Addition of *E. aerogenes* increased overall amount of produced hydrogen. Obtained results showed potential of *E. aerogenes* for use in bioaugmentation purposes for fermentation of glycerol. Lake sludge inoculum contained microorganisms necessary for the production of hydrogen as well as biogas from glycerol. Clostridia and Gammaproteobacteria were predominant in the inoculum. Cultivable bacteria *Bacillus licheniformis*, *Burkholderia cepacia*, *Hafnia alvei* and unidentified *Clostridium* species were found to be predominant after six days of fermentation.

**Key words:** bacteria, bioaugmentation, fermentation, inoculum.

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## Biomass yield and chemical composition of *Phalaris arundinacea* L. using different rates of fermentation residue as fertiliser

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**Abstract.** Using biomass of various crops for bioenergy production is a common practice all over the world. Grasses, including reed canary grass (*Phalaris arundinacea* L.), as bioenergy crops have many advantages. Therefore it is important to look for the most effective technology to produce high biomass grass yields taking into consideration the quality parameters important for this purpose, and at the same time providing sustainable plant nutrient recycling schemes. The use of fermentation residue (FR) from biogas plants as fertiliser could be environmentally and economically cost-effective, as this by-product contain considerable amount of plant nutrients. However, there is little research on the efficiency of FR use for grassland. In our experiments we evaluated the effect of FR used at different rates (from N0 to N150 kg ha<sup>-1</sup>) and different treatment techniques (once/ twice/ or three times per season) on the productivity of RCG under two-cut and single-cut harvest regime. The data of three ley years (2012–2015) show that annual dry matter yields ranged from: 3.93–11.44 t ha<sup>-1</sup> in two-cut and 5.89–13.94 t ha<sup>-1</sup> in single-cut regime. The highest dry matter yield was obtained using FR at: 60 kg ha<sup>-1</sup> N using the entire amount in a single application at the beginning of the season; 120 and 150 kg ha<sup>-1</sup> N split for three applications. The chemical composition of reed canary grass biomass was mostly influenced by harvest regime: late harvest at single-cut regime ensured more appropriate sward quality for bioenergy production with a higher carbon and lower ash, nitrogen, potassium and phosphorus content.

**Key words:** dry matter yield; fermentation residue, fertilisation, *Phalaris arundinacea* L.

## Second-generation bioethanol production: A review of strategies for waste valorisation

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**Abstract.** This paper reviews second–generation biofuel production chain and focuses on its energetic, economic and environmental impacts. The biggest challenge in the production of bioethanol from lignocellulosic material refers to the biomass waste that is left over after the separation of bioethanol in the distillation process. This waste still has high energetic value and could be further utilised to add value to the production chain. Furthermore, the environmental impact of untreated waste from bioethanol production is very high, which also requires attention. Anaerobic digestion of bioethanol production waste has been proposed as a possible solution to utilise the energetic potential of this waste and lower its environmental impact.

**Key words:** lignocellulosic biomass, biofuel, anaerobic digestion, zero–waste, ERoEI.

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## Technical solutions used in different pretreatments of lignocellulosic biomass: a review

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**Abstract.** Bioethanol production from lignocellulosic biomass has attracted a lot of attention as one of the most promising alternative to liquid fossil fuels. Over the last decades a lot of research has been done to find the optimal methods & devices to produce bioethanol from all kind of lignocellulosic biomass. A traditional three-step production process is used to produce bioethanol from lignocellulosic biomass – pretreatment, enzymatic hydrolysis, & fermentation. Today, the high cost of the pretreatment prevents bioethanol from competing with petrol. In this review article, the positive & negative aspects of different pretreatment methods & patented devices are investigated & analysed. Based on the analysis several options on how to lower lignocellulosic biomass pretreatment costs & how to increase the competitiveness of bioethanol are proposed.

**Key words:** bioethanol, pretreatment devices, pretreatment methods, biomass.

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## Quantification of biogas potential from livestock waste in Vietnam

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**Abstract.** Quantification of biogas potential in Vietnam is highly needed to provide sufficient information for authorities properly support their future policy decisions. To achieve the aim of this investigation, two methods were applied: (i) the method for calculation of the amount of manure and its biogas potential from chosen livestock obtained from statistical data and (ii) the method for future forecast using middle scenario applications based on previous development of specific category, presuming homogenous continuation of growth. The total biogas energy potential in Vietnam was quantified to approximate 120,000 T Jy<sup>-1</sup> in 2015 and has the potential of increasing to 127,000 T Jy<sup>-1</sup> by 2020. However, when considering current manure management practices (including accessibility factor and collection efficiency) biogas potential was quantified to the values of almost 67,000 T Jy<sup>-1</sup> in 2015 and over 71,000 T Jy<sup>-1</sup> by 2020 if the current manure management practices remain unchanged. Biogas has the potential of generating renewable energy, while meeting requirements related to waste treatment and minimizing environmental impacts. This study shows that animal waste is a promising sustainable energy source in Vietnam which can be efficiently utilized for the generation of biogas energy as well as electricity. Furthermore, anaerobic digestion of livestock waste has the potential to play a vital role in farming systems by adding value to agricultural waste and livestock excreta, and reducing their presence in the environment therefore enhancing public health. There is a high development potential for the decentralized energy generation due to the exploitation of small-scale biogas plants in Vietnam. However, it is essential to realize that competition to other energy generating technologies is present.

**Key words:** biogas potential, quantification, biogas, Vietnam, livestock waste, anaerobic digestions, manure management

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## Biomass combustion research studying the impact factors of NO<sub>x</sub> formation and reduction

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**Abstract.** Aim of this study was to identify potential NO<sub>x</sub> reduction factors and determine impact of nitrogen quantity in the fuel, during combustion process and conversion to nitrogen oxides. Experiments were performed using moving grate biofuel boiler with two staged air inlets, which represents industrial boiler operating principles. Combustion was performed using agricultural wastes: grain middlings, buckwheat hulls, corn pellets and mixtures with wood pellets. These types of fuels in combustion process generate about two times bigger amount of nitrogen oxides than wood pellets. The result of research shows, that the amount of nitrogen in the fuel has the greatest impact for NO<sub>x</sub> generation compared to all NO<sub>x</sub> formation forms. It was found that a smaller quantity of nitrogen, has bigger impact factor, than higher quantity of nitrogen, in biomass, for NO<sub>x</sub> formation during combustion. It was noticed that during combustion process the amount of carbon monoxide is inversely proportional to NO<sub>x</sub> values. The impact factor of nitrogen conversion to NO<sub>x</sub> and CO potential of reducing NO<sub>x</sub> is presented by formula in this paper.

**Key words:** biomass combustion, NO<sub>x</sub> formation, CO.

## Effects of nutrient supply and planting material quality on yield and survival rate of a short rotation coppice culture in Hungary

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**Abstract.** In May 2011, a short rotation woody energy plantation (SRC) was established near Dejtár village in Northern–Hungary. The goal of the experiment was comparative analyses of different fertilization treatments on three clones of *Populus* (AF2, Monviso, Pannonia) and one *Salix* cultivar ('Dékány'). We used three fertilization treatments: (1) 5 t ha<sup>-1</sup> of wood ash, (2) 40 t ha<sup>-1</sup> of farmyard manure and (3) both 5 t ha<sup>-1</sup> of wood ash and 40 t ha<sup>-1</sup> of farmyard manure. The Monviso clone had the highest survival rate (92%), followed by Pannonia (80%) and AF2 (78%). Initially, the white willow 'Dékány' cultivar was also included in the experiment, but due to differing site preferences of this cultivar, it was not viable in the area. Based on the data of the first three growing seasons, it was demonstrated that the important nutrients had already been present in optimal amounts from the start of the experiment, and their contents were increased due to the treatments. At the end of the first growing season, the effect of the fertilization treatment could not be detected, but by the third year the results showed a significant positive effect. Already in the second, but mostly at the end of the third growing season, the wood ash + manure fertilizer treated plots showed significant increases in height growth and biomass yield.

**Key words:** *Populus* Spp; Farmyard manure; Wood ash; Biomass production.

**ACKNOWLEDGEMENTS.** This study has been supported by the Ipoly Forestry cPlc, Hungary.



## Alcohol recovery from fermentation broth with gas stripping: system experimental and optimisation

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**Abstract.** Effective liquid biofuel production from various lignocellulosic waste resources is dependant not only on pre-treatment and hydrolysis but also on effective removal of alcohols from the fermentation media. Distillation and rectification is not suitable in low alcohol content systems (butanol production with clostridia) or in cases when the fermentation is performed in a continuous mode. One of the technologies offering continuous, *in situ* removal of alcohol is gas stripping. Despite the recognition of this technology, it is still under evaluation and adjustment. Thus, the aim of this study was to evaluate if gas stripping technology at rapid flow conditions is efficient enough to recover ethanol from the fermentation media. The results showed that  $60 \text{ l min}^{-1}$  flow rate was optimal to recover more than 45% of the available ethanol in 8 hours of stripping with nitrogen gas. The technology was efficient if the ethanol content in the fermentation broth was 10 wt%. At lower concentrations the recovery showed to be inefficient. Application of  $\text{CO}_2$  as the stripping gas was not suitable for ethanol recovery and should be tested prior use. In conclusion, the application of rapid  $\text{N}_2$  flow rate for gas stripping of ethanol from fermentation media showed to be an efficient technology and could replace long time, low flow rate stripping.

**Key words:** lignocellulosic biomass, biofuel, gas stripping, alcohol recovery.

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## Hydrolysed biomass waste as a potential biosorbent of zinc from water

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**Abstract.** In the last 10 years recycling of various materials and metal recovery from waste with low cost biosorbents or agricultural biomass has become popular trend. Lignocellulosic biomass is regarded as a sustainable resource for biofuel production. In this process, lignocellulosic biomass is partly degraded during chemical or biological hydrolysis, as a result, these agricultural waste materials usually present a disposal problem and have no economic value. Therefore, reuse of lignocellulosic waste materials as inexpensive and alternative sorbent for heavy metals in polluted aqueous solution.

The aim of this research was to evaluate the applicability of hydrolysed biomass waste for zinc removal from water solution. To evaluate the potential use of lignocellulosic biomass for biosorption, experiments were performed with dry, washed from organic matter and hydrolysed hay. The results showed that hydrolysed hay have lower biosorption capacity than washed and dried hay, however, it still can be used as a low-cost biosorbent for the removal of Zn in polluted aqueous solutions, because it showed relatively high zinc sorption capacity (336–391 mg g<sup>-1</sup>).

**Key words:** biosorbent, lignocellulosic biomass, waste, heavy metal, zinc.

**ACKNOWLEDGEMENTS.** This work has been supported by Latvian National Research Programme LATENERGI. No. 2014.10-4/VPP-1/27.

## **IV ERGONOMICS**

## Skeletal muscle tone and motor performance characteristics in dentists as compared to controls

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**Abstract.** The daily work tasks of dentists are associated with repeated movements and static load during the treatment of patients. Dentists' profession includes manual dexterity and maintaining the occupational posture for a long time. Previously it has been noted that dentists have increased muscle stress in neck, shoulder and lower back regions. The aim of the present study was to compare the muscle tone and motor performance characteristics of neck and shoulder region in dentists and representatives of other professions who do not have similar static load of long-time duration (as controls). Twenty women aged 34–55 years participated in the study: ten dentists with the age (mean and SE) of  $40.2 \pm 3.9$  years and ten controls (bookkeepers, security guards, office workers, printing house workers, laundry and dry cleaning workers) with the age of  $40.9 \pm 2.4$  years; working period was on the average 14 years in both groups. The tone characteristics of *m. trapezius* and *m. extensor carpi radialis* were investigated by device Myoton-2 (Müomeetria Ltd, Estonia) at rest and at maximal voluntary contraction (MVC) in sitting position at the workplace of participants. The cervical range of motion (CROM) and the handgrip strength were measured. Significantly higher ( $P < 0.05$ ) tone and elasticity characteristics of *m. extensor carpi radialis* and lower ( $P < 0.05$ ) tone and elasticity characteristics of *m. trapezius* at rest were noted in dentists compared to controls. At MVC, no significant differences were found in the studied characteristics between body sides in the measured groups. Dentists had lower ( $P < 0.05$ ) CROM of flexion and rotation than controls. In dentists emerged significant difference in muscle elasticity characteristics for the right body side, this is related with stretching for dentistry instruments.

**Key words:** muscle tone, muscle elasticity, handgrip strength, range of motion, dentists.

**ACKNOWLEDGEMENTS.** Authors thank Ms Mare Vene for language correction. This study was partially supported by the Estonian Ministry of Education and Research project 'Physical performance and health: adaptational and age-related aspects' IUT20–58.

## The search for practical and reliable observational or technical risk assessment methods to be used in prevention of musculoskeletal disorders

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**Abstract.** Work-related musculoskeletal disorders (WRMSDs) are still frequent, inducing very large costs for companies and societies all over the world. Ergonomists work to prevent these disorders and to make organisations sustainable. In their work it is important to identify risks in a reliable way, to prioritise risks, and then to perform interventions (participatory interventions have shown to more often be successful), so that the risks and the disorders may be reduced. Risks are most often assessed by observation. Two projects are described. In the first project the inter-observer reliability of six observational methods was found to be low in risk assessments concerning repetition, movements and postures. Also the inter-method reliability was often low, i.e. when the same work is assessed with different methods different risk estimates are often obtained. In the second described project, easy-to-use methods for measurements of postures and movements were developed and validated. Hence, there are now validated technical methods that are easy to use. But, today's inexpensive electronic devices should be utilized to a higher degree, in developing tools, together with practitioners, that are attractive, easy and time efficient to use, and which should increase the reliability in risk assessments of work tasks and jobs.

**Key words:** Biomechanical exposure, Observation, Direct measurements, Validity, Reliability, Usability.

**ACKNOWLEDGEMENTS.** The projects reported, the evaluation of observational methods, and the development and evaluation of technical methods were supported by the Swedish Research Council for Health, Working Life and Welfare (FORTE project no. 1212–1202), and AFA Insurance (Dnr: 120237), respectively. I am also thankful for all work by all co-workers in those two projects, who were in the first project: Ida-Märta Rhen, Kristina Eliasson, Teresia Nyman, Peter Palm, Katarina Kjellberg, Per Lindberg, Natalja Balliu and Xuelong Fan; and in the second project: Camilla Dahlqvist, Liyun Yang, Jens Wahlström, Carl Lind, Wim Grooten and Gert-Åke Hansson.

## Improving job satisfaction with different intervention methods among the school personnel in Estonia and Latvia

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**Abstract.** This investigation was carried out in two high schools: one in Estonia (EST1) and one in Latvia (LAT1). The offices EST2 and LAT2 were chosen from the countryside of the both countries. Office EST1 is situated in an atrium-type building for educational and research needs. The second building is mainly for education (auditoriums) and the offices LAT1 are situated on the ground floor. The third and the fourth offices were taken for comparison. Office EST2 is situated in a countryside in an old wooden building; the fourth office LAT2 is located in a new building in Latvian countryside. All together 181 office-workers were involved. At first, the work environment conditions were measured. The ergonomics of workplaces was assessed with ART-tool and Kiva-questionnaire was used to study psychosocial conditions and job satisfaction at computer-equipped workplaces. Occupational hazards were measured to clarify, do the work environment influence on the behaviour and the job motivation and satisfaction of the worker at workplace? After the first questioning of workers using Kiva-questionnaire, the Metal Age programme was implemented and after the intervention, the Kiva-questionnaire was carried out again. The results showed that if the preventive measures for solving the problems at workplace are implemented, and the employers and the employees are trained and consulted using the appropriate programmes, the stress situations could be avoided. The workers in all offices were confident that the discussion about the problems is very important as the work with computers is intensive and there is a very short time to communicate with each other. The educational work is also stressful.

**Key words:** work conditions, ergonomics, computer-use, psychosocial climate, high-schools.

## Evaluation of the actual sitting position of drivers of passenger vehicles

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**Abstract.** This paper is concerned with comparing the actual sitting position of drivers of passenger vehicles with the position commonly considered optimal from the viewpoint of active and passive safety, and the long-term effects on the driver's health. The research described herein was conducted on a sample of randomly selected drivers in Czech Republic. All the measurements were conducted in a single, neutral, medium-sized passenger vehicle with which none of the test subjects had any previous experience. For this reason, none of the tested drivers had the advantage of familiarity with the environment. This research came about as an attempt to re-create the common situation wherein a driver adjusts his/her position behind the steering wheel solely on the basis, of intuition. Through a statistical evaluation of the acquired data, it was possible to confirm the initial hypothesis that a substantial portion of tested drivers assume a less than optimal driving position. This fact has a negative effect not only on reducing active and passive safety, but directly impacts upon the health of drivers who cover high annual mileage. The results of this paper can be used when designing cabins and modern interactive systems for passenger vehicles, which will be able to assist the driver in setting the optimal driving position. In this way, it will be possible to directly impact upon traffic safety and positively influence drivers' health.

**Key words:** Driver, Seat, Position, Sex, Physiological Optimum.

## Ergonomic intervention programs in different economic sectors: a review article

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**Abstract.** Unlimited number of hazards can be found in almost every workplace increasingly causing work-related diseases (WRDs) and injuries among workers. In work environment there are various risk factors: physiological, physical or psychological. An awkward and static postures, repetitive movements, high work pace, non-ergonomic tools and poorly organized workstations are most likely causing musculoskeletal disorders. As well inconvenient room temperature, noise, vibration and poor lighting conditions can conduce to additional work discomfort, mental stress, fatigue, injury, or trauma among employees. Ergonomic interventions are coming more popular. Many organizations are trying to find best solutions to avoid musculoskeletal disorders (MSD). The aim of this paper is to describe different ergonomic interventions focused on diminishing of musculoskeletal discomfort and MSDs among workers. This paper gives overview about the most common and effective ergonomic interventions which really have worked in practice. For this research were used three different databases EBSCO, Science Direct and Mendeley. The selection of publications passed three phases of systematic search of literature: the first elimination consist of keywords 'ergonomics, intervention' and year of publication. In the second phase was added a keyword 'work' and in the third phase were eliminated repeated and literature review publications and as well publications which had little sample size or the exploration was not covered with real interventions. The publications (n = 209) of ergonomic interventions carried out in the past five years 2010–2015 were analyzed. Wide spectrum of different ergonomic interventions was found in several economic sectors, whereas the most effective ones were related to well-known ergonomics methods, workstation adjustment, training and exercises.

**Key words:** ergonomic interventions, ergonomically designed workplaces, musculoskeletal disorders.



## **Influence of air-conditioning on dust level in drivers' cabin during the harvest of grain**

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**Abstract.** The period of grain harvest is characterized by dry and hot summer weather. During the grain harvest is generated large amount of dust which significantly influences surroundings, but mainly drivers are exposed to dust pollution. The aim of this paper is to present results of microclimatic research focused on dust pollution in drivers' cabin of tractors and combine harvesters of different construction used for harvest of grain. The machinery selected for this research includes the old but also very modern tractors and combine harvesters which are equipped with air conditioning. In the frame of this research the concentration of air dust was measured by exact instrument DustTRAK II Model 8530 aerosol monitor. Using the special impactors the  $PM_1$ ,  $PM_{2.5}$ ,  $PM_4$ ,  $PM_{10}$  size fractions were also measured. Obtained results of measurements were evaluated and concentrations of different size of dust particles were analysed. Results of different indoor conditions measured in new and old machinery are generalized.

**Key words:** combine harvesters, grain dust, indoor of cab, measurement, tractors.

## Occupational diseases among agricultural workers in the Russian Federation: statistical data

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**Abstract.** The aim of the study is to analyze the epidemiological situation of occupational diseases among agricultural workers in Russia. To address this task, the analysis of occupational diseases incidence was carried out.

**Conclusions.** For the last decades the proportion of rural working population in Russia is gradually decreasing, but remains noticeably higher than in other industrialized countries. There is a huge difference between entities of the Russian Federation in occupational illnesses incidence rates among agriculture workers, which can be explained by: (a) the distinction of health care availability; (b) lack of occupational physicians in several rural areas; (c) the high level of the incidence of non-communicable diseases, which can disguise occupational illnesses among agricultural workers. The improvement of health care regulatory legal framework, postgraduate education of medical doctors in rural areas in occupational health, and implementation of health promotion programs are necessary in order to maintain the health of agricultural workers.

**Key words:** agricultural workers, occupational diseases, diagnosis.

## Verification of mathematical model of pressure distribution in artificial knee joint

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**Abstract.** The paper deals with pressure distribution measurement in knee arthroplasty, which is an artificial replacement of human knee joint. The scope of the article is to verify the accuracy of a mathematical model by real measurements. The calculated pressure values basing on the mathematical model are compared with actually measured pressure values in the contact area of the joint. Hereby maximal load the in the contact area, the distribution of the pressure and any potentially dangerous pressure deviations during the walk cycle are checked. To enable accurate pressure distribution measurement without interfering into human's body, a sophisticated measuring setup was created: the contact area of the joint was equipped with several pressure sensors and a machine simulating the human walk cycle was used. The measured pressure data are finally compared with those from the mathematical model and with the strength limit of the used material, to verify the accuracy of the mathematical model experimentally.

**Key words:** knee arthroplasty, force sensor, artificial joint, pressure distribution, strain gage, tibial plateau.

## Effectiveness of simulation models on technical skills among surgeons. A critical review

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**Abstract.** Based on simulation models the surgeons can train technical skills and improve their functional status of musculoskeletal state. Work in good ergonomic position could reduce and prevent musculoskeletal disorders. The aim of this review is to carry out critical analysis of research on simulation techniques analysing the effectiveness of simulators on technical skills among the surgeons. The search of the articles based on the databases EBSCO, Science Direct and Web of Science. The articles published in 2011-2016 years and not the literature reviews of simulator models in surgery were the selection criteria. Most often the simulator models have used for training of laparoscopic operations, choosing new instruments or introducing new methodologies. Some articles have paid more attention to ergonomic equipment layout in practice to prevent musculoskeletal disorders. It is important to use simulators in the university hospitals, where the young surgeons and medical students are practicing.

**Key words:** ergonomics, simulator, surgeon, skills.

## Work strain predictors in construction work

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**Abstract.** The aim of this study was to predict the work strain indicators for construction workers and to work out measures for prevention of strain at work. Subjective and objective research methods were utilized in the research, including survey, work intensity measurements (Borg Scale), work strain index, fatigue index and work ability index determination, objective blood pressure and pulse measurements. Statistical analysis with significance calculations was carried out. The limitation of this study is the small number of subjects involved in the research. Subjective evaluation of fatigue index and strain index resulted in moderate and somewhat hard work heaviness categories accordingly to Borg Scale. Measurements of heart rate, blood pressure approved work strain of employees of both professions does not exceed the admissible heart rate limit during physical load. The research proved that the strongest work strain predictors were connected with psycho-social risks rather than with physical ones.

**Key words:** fatigue, work heaviness, auxiliary workers, road workers, heart-rate, blood pressure.

## Musculoskeletal discomfort in association with functional and work characteristics of upper limbs in female supermarket cashiers

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**Abstract.** *Introduction.* Last year Estonian Labor Inspectorate reported that occupational diseases are highest in trade business, including supermarket workers. Lifting heavy loads, repetitive work tasks, unergonomic work positions with static sitting are main reasons for occupational diseases. These risk factors are main in cashiers work causing musculoskeletal discomfort (MSD), while they are working long hours in a sitting position. The aim of this study was to assess MSD in association with functional and work characteristics of upper limbs in female supermarket cashiers.

*Subjects and methods.* Thirty Estonian female supermarket cashiers with mean age ( $\pm$  SD) of  $40.5 \pm 14.3$  yrs, with body mass index  $25.2 \text{ kg/m}^2$  participated in this study. All subjects worked in sitting position almost whole 8-hours workday. Work characteristics was assessed by rapid upper limb assessment (RULA). Upper limb function was assessed by hand and finger grip strength using dynamometers. Participants filled the standardized Nordic Questionnaire to evaluate MSD and informative form concerning bio-demographic variables.

*Results.* Cashiers perceived MSD in neck (43.3), in shoulders (36.7%), in wrist (26.7%), and in elbow (20%) during the last 6 months. According to RULA test, total risk score was 4, which shows low level of risk, but changes might still be necessary. Highest scores were noted, when cashiers reaching money and invoice to customers. Hand grip strength for right hand was 5.5% greater than for left hand, whereas finger grip strength for right hand was 7.6% greater than for left hand. Upper limb work characteristics assessed by RULA test correlated with MSD during the last 7 days in elbow ( $r = 0.37$ ;  $p < 0.05$ ) and in wrist ( $r = 0.28$ ;  $p < 0.05$ ).

*Conclusions.* Cashiers perceived higher musculoskeletal discomfort in neck, shoulders, wrist and elbow. They had low risk for postural overloading in upper limb. Work characteristics are associated with acute musculo-skeletal pain in elbow and in wrist. To avoid musculoskeletal discomfort in upper limb, cashiers should pay attention on their health by following ergonomic guidelines.

## Operator's behaviour measuring methodology inside off-road vehicle cabin, Operator's focusing scheme

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**Abstract.** Operator's workplace design takes a priority to be developed in order to reach the highest possible level of Quality, Safety and productivity. Continual improvement of the workplace is yield from studies carried out on different approaches, each approach shall keep into consideration many aspects, in this research; the results will be used for feeding the productivity aspects with valuable and reliable input data using relatively simple engineering solutions. This research is made based on literature of the accumulated knowledge from diverse fields in which different studies and analysis are made to provide the necessary input for Human Centred Design process, adopting the-state-of-the-art technologies and methodologies used for data collection and analysis for Human behaviour inside the dedicated workplace. Better understanding of the operator's Gaze in addition to the change according to the mental and physical workloads inside the tractor cabin will lead to optimal designs for higher productivity operation.

**Key words:** off-road vehicle, operator's behaviour, eye tracking, focusing scheme.

## Substantial factors influencing drivers' comfort in transportation

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**Abstract.** Research shows that driver stress is associated with workload and fatigue, and an inappropriate microclimate in the driving cabin can have an impact on overall driver's safety. The aim of this scientific study is to examine whether driver stress, across various urban and field drive conditions, can affect performance in a confined environment and whether the natural breathing process can also compound these effects and aggravate health hazards. This paper will address the influencing parameters associated with driver comfort of everyday job occupations in the urban communication network of Prague city public transport. In this research paper the authors will characterize cardinal components directly accountable to the safe operation elements; the concentration of carbon dioxide (CO<sub>2</sub>) and the relative humidity (Rhi) in the driving cabin, affecting the contentment of the drivers comfort while performing their duties. Similar inquiries were carried out on ventilation emphasis and air intake impact in drivers' cabin, recommending a design to minimize safety problems associated with comfort. Data on the concentration of carbon dioxide and internal relative humidity in the respective cabins have been collected carefully for detailed analysis. This research paper is the outcome of these findings.

**Key words:** driver, bus, tram, metro, microclimate, ventilation.



## Prevention the Impact of Chemicals on the Health of Workers in Fibreglass Industry

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**Abstract.** Most of the chemicals make our everyday life easier and safer. However, there are a lot of new emerging risks connected with chemicals causing damage to people's health and environment. The results of the investigation: the chemical exposure index (EI) is between 0.16 to 25.98 (the last determined by the mould spray-up, outside of the protective masks). The air pollution index determined was between 16 to 760%. The ventilation rates for the remove of the volatiles from the workplace air are settled, the possibilities for substitution of hazardous chemicals to less hazardous are presented. When the concentration of a volatile is measured under the protective mask, which has a new filter, the tested substance concentration is lower that under the mask with an old filter, although the differences between these two were rather small. When the volatiles were measured under the protective mask, the concentrations of tested substances met the requirements.

**Key words:** chemicals' hazardousness, health risks, solvents, substitution.

## **V LIVESTOCK ENGINEERING**

## Effect Of Slurry Lagoon Redesign On Reduction Of Ammonia Emission During Livestock Manure Storage

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**Abstract.** In accordance with the international and EU aims to reduce emissions of ammonia and other air pollution substances farm manure management, including its storage, especially for the animal breeding sector, is one of the most essential stages. One of the preventing steps is covering of the slurry lagoons. The most effective – hard covering can be provided only after the lagoon is constructed. The aim of the research: to develop methodology for calculations of emission reducing lagoon design volume and surface area. In the result of the theoretical research the possibilities of reducing the reflection surfaces at the same capacity of the lagoon have been discovered, as well as the changes of the reflection surface area, if instead of one lagoon several lagoons with less volume are installed and sequential filling of these lagoons is ensured. The article presents the calculation algorithms obtained during the research and recommendations for construction of low emission lagoons.

**Key words:** manure, lagoon capacity, modelings

## Evaluation of the surface temperature of laying hens in different thermal environments during the initial stage of age based on thermographic images

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**Abstract.** The initial stage of laying hens requires important care in relation to the thermal environment, in view of the good development of the birds, the obtaining of good quality pullets and, consequently, the adequate laying rate of adult birds.

The aim of the present study was to study, through thermographic images, the variation of the superficial temperature of laying birds of the Lohmann LSL Lite line, from one to forty-two days of age, submitted to different thermal environments. For this experiment, 864 layer chicks were distributed homogeneously in four climatic chambers. The characterization of the different environments was as follows: thermal comfort conditions (32.8 °C–20.2 °C), two cold stress levels (28.0 °C–17.9 °C and 25.5 °C–17.3 °C) and one level of heat stress (37.4 °C–23.3 °C). The black globe temperature and humidity index (BGHI) was also calculated during the trials. The data were evaluated through the Tukey test, adopting the level of 5% of probability. Via infrared thermography the temperatures of head, body and shank of the laying birds were recorded. The results showed effect ( $P < 0.05$ ) of the temperature of each environment on the surface temperature of the birds. Along with the rise of the ambient temperature, an increase in the surface temperature (head and shank) was found.

Under the recommended comfort treatment, the performance of laying birds during the early-stage, related to the superficial temperature of the birds shows the best values with temperature ranges of 32.8 °C–20.2 °C and BGHI values between  $82.3 \pm 1.3$  and  $66.4 \pm 1.3$ .

**Key words:** environmental conditions, surface temperature, poultry, layer chicks, images analysis, infrared thermography.

**ACKNOWLEDGEMENTS.** To CAPES, CNPq, FAPEMIG and the LOHMANN do Brasil.

## Supply of wood as environmental enrichment material to post-weaning piglets

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**Abstract.** Slatted flooring is a common system used for post-weaning of piglets. In this condition of breeding, it is very hard to provide materials for environmental enrichment to enable proper investigation and manipulation activities to improve animal welfare.

The research aimed to identify an alternative way to provide natural environmental enrichment during post-weaning on slatted flooring using wood. Core of veneer poplar logs and wood sawdust pressed briquettes were selected among other types of wood thanks to their wide availability and low cost. Moreover, these kinds of wood can be used without compromising the health of the animals, neither by contact nor by ingestion.

The most important step of the research was to design systems to make the wood more attractive for piglets. The developed devices consisted of a fixed structural component to be installed inside the pen to which wood materials could be added and replaced quite effortlessly.

Three devices were developed: a) horizontal system, b) vertical system, c) pendulum system. They were tested in three different pens, each one with 24 post-weaning piglets.

The results confirmed the assumption that there is a relation between the level of activity of the animals and the interaction with the wood proposed in the shape of small logs and briquettes. In particular the device a) can generate a valuable level of interaction of the animals reared inside the pen, especially in the first 10 days post-weaning, which is the most sensitive period for piglets after mixing.

**Key words:** Slatted flooring, piglets, welfare, environmental enrichment, wood, briquettes, poplar logs.

**ACKNOWLEDGEMENTS.** This work was supported by Progetto AGER, grant n. 2011–0280.

## Method of designing of manure utilization technology

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**Abstract.** Specific feature of modern livestock farms is concentration of a large number of animals and subsequent significant environmental load. The biggest negative impacts are on the atmosphere through ammonia emissions and on water bodies through nitrogen and phosphorus compounds leakage, with manure being the major source of these pollutants. The proper choice of an effective low-cost manure handling technology with high nutrients retention ensures the environmentally sound operation of these farms. With this aim in view a designing method of manure utilization technologies is proposed. Relevant available technologies were reviewed, a mathematical model was created and technology assessment criterion was defined. Manure utilization technology is understood as a set of activities, including manure processing, manure storage (if necessary) and soil application of organic fertilizers. To create a mathematical model 12 manure utilization technologies were examined. These technologies are based on various methods of manure processing, such as long-term maturing, composting, biofermentation, separation into fractions, drying and biogas production. The created mathematical model takes into account the economic and environmental performance of each technology. The proposed approach makes it possible to calculate and compare the level of nitrogen preservation in manure and required inputs for different technologies depending on the farm animal stock. To assess and select the most suited technology the eco-efficiency criterion is suggested, which takes into account the yield increase, the cost of generated energy (for biogas production), and reduced negative impact on the environment. The paper presents example of using the method to make a choice of technologies for a dairy farm. Experience in the use of the method shows that the average values of nitrogen preservation in the manure, which may be achieved without involving excessive costs, are 72% for cattle manure, 70% for pig manure and 78% for poultry manure.

**Key words:** environmental safety, technology assessment, utilization of manure technology, technology designing, best available technique.

## Evaluation of nutritional and physical values of pellets based on pea and lupine with added yeast in chickens fattening

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**Abstract.** The article is focused on the development of the new type of broiler chicken feed, based on pea (*Pisum sativum* L.) and blue lupine (*Lupinus angustifolius* L), enriched with used dried brewer's yeast. This composition eliminates use of soybean meal (PES) that was yet a traditional component in chicken feed. The main reason for its elimination was the using of genetically modified varieties of soybean and its relatively high price around 0.5 Euro kg<sup>-1</sup> in Czech Republic. For milling of pea or blue lupine was used vertical (hammer) mill type Taurus, supplied by company TAURUS, for drying of used brewer's yeast had been used drier Memmert UFE 800, final dry matter of the yeast was 88%. For pellets production were used two devices, press type JGE 120-6110 and Testmer. For the determination of physical properties of manufactured pellets (the weight of 1,000 pieces, bulk density, abrasiveness and pellet durability index PDI) were used following laboratory devices, Pellet Tester Holmen NHP and Testmer 200. Experimental activities had shown that the best results were reached using pellets manufactured on base blue lupine enriched by dried brewer's yeast (6%).

**Key words:** broiler chicken, feeding, blue lupine (*Lupinus angustifolius*), pea (*Pisum sativum*), used dried brewery yeast, pellets, mechanical properties, weight of 1,000 pellets, bulk density, abrasiveness, pellet durability index (PDI).

## Lifetime milk productivity and quality in farms with different housing and feeding systems

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**Abstract.** Housing and feeding systems in farms are main factors that affects cow milk productivity and its quality. The largest proportion of Latvian farms are small farms with tie stall housing system and grazing in summer. The aim of our study was to determine to what extent different housing and feeding systems affect the milk productivity, quality and cow longevity characterizing traits of Latvian dairy cows. In study we analysed 3,179 Holstein Black and White (HBW) and Latvian Brown (LB) breed cows from which 2,383 were located in 2 farms with loose housing system and TMR feeding and 796 cows were located in 8 small farms with tie stall housing system and different feed in summer and winter periods. The average daily milk yield significantly higher ( $p < 0.05$ ) were in farms with loose housing system – 23.53 kg ECM, but in farms with Tie stall housing system was obtained 18.46 kg ECM per day. HBW breed cows characterized with lower somatic cell count in milk than Latvian brown in both housing systems. The highest somatic cell count in milk was obtained from third lactation LB breed cows in Tie stall housing system (249.11 thous. in  $1\text{mL}^{-1}$  milk) and the lowest from HBW cows in loose housing system (127.57 thous. in  $1\text{mL}^{-1}$  milk). Cows in smaller farms characterized with longer lifespan – 2,098.7 and 1,890 days for large farms, but lifetime milk productivity was significantly higher in farms with loose housing system where was obtained 21,315.9 kg ECM whereas in Tie stall system farms average life productivity was 19,740.2 kg ECM.

**Key words:** Housing systems, milk productivity, milk quality, longevity.

**ACKNOWLEDGEMENTS.** For financial support during preparation of study: National Research Programme Project 2014–2017. Agricultural Resources for Sustainable Production of Qualitative and Healthy Foods in Latvia. *Project No. 3* Genetic research on local dairy cows and pigs economically important traits.



## Correlation between egg quality parameters, housing thermal conditions and age of laying hens

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**Abstract.** High environmental temperatures cause a decrease in feed consumption by laying hens and, as a consequence, a reduction of productive performance and egg weight. The hens age is a factor influencing the albumen quality that tends to be more liquefied in older hens. Such variable is analysed by the determination of the Haugh Unit.

The correlations between the egg quality variables (egg weight and Haugh Unit), the thermo-hygrometric conditions in the facility and the age of laying hens were determined in the study and evaluated based on the Pearson correlation coefficient ( $r$ ) and their significance at the 5% level. The microclimatic data and the eggs were collected in 20 points of poultry facility with birds of 43, 56, 69, 79 and 86 weeks of age, totalling 100 samples.

The results show significant correlations between egg weight and temperature ( $r = -0.238$ ), egg weight and hens age ( $r = 0.310$ ), Haugh Unit index and hens age ( $r = -0.256$ ); a non-significant correlation between the quality parameters with the relative humidity of the air inside the barn.

The egg weight had a weak negative correlation with the ambient temperature and a weak positive correlation with the hens age. Concerning the Haugh Unit, a weak negative correlation with the age of the animals was found. The weak or non-existent correlation of temperature with egg quality parameters can be due to the environmental conditions that remained in the range of thermal comfort for the animals during the trials.

**Key words:** environmental conditions, thermal comfort, poultry, laying hens, egg quality.

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## Evaluation and optimization of milking in some Polish dairy farms differed in milking parlours

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**Abstract.** Farms are continuously growing and modernized in Poland during the last years. The increased dairy herds require also modernization of milking equipment. The aim of this paper was to present the main criteria, which could be used for the solution of principal questions important for the choosing, optimization and evaluation of milking parlours in conditions of Polish agriculture. The research was conducted on three modern dairy farms in Poland to assess effectiveness of different milking parlours use. The first farm with 60 cows was equipped by side by side milking parlour, the second farm with 85 cows was equipped by herringbone milking parlour and the third farm had 80 cows and autotandem milking parlour. The choosing and evaluation of milking parlours parameters were based on the available information and results of previous research in dairy farms in the Poland, using the mathematical model created in the Czech Republic. Time for milking and final specific direct costs were main parameters which enable evaluation and choosing of suitable milking parlour for the dairy farm. The results of measurement and calculation in current farms were compared with possible future enlarged farms to capacity of 200 cows.

**Key words:** milking parlours, dairy farms, costs, cows, milking process.

## Assessment of dairy cows herd indices associated with different milking systems

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**Abstract.** The objective of the investigations was to consider the idea if there are any differences between cattle herds operated by some kind of milking installations. The cattle herds were identified not only by herd size but also some data like annual milk yield, age, number of lactations. Data collected on dairy farms which operate pipeline milking systems, milking parlours and automatic milking systems were analysed. These farms are located in three Baltic States. It was found that some indices concerning dairy cattle herds are associated with different milking systems and can be used to analyze milking efficiency. Decrease tendency in percentage of udder diseases with increase in cow herd size was found in some dairy farms.

**Key words:** AMS, cow herd, dairy production, milking parlour, pipeline milking system

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## The effect of immunomodulation composition on systemic immune response and udder health in case of bovine subclinical mastitis

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**Abstract.** Modulation of mammary gland immune response may offer an alternative to antimicrobial therapy in the treatment of subclinical mastitis. The aim of the study is to investigate the systemic immunomodulating effect and the impact of composition LLG which consists of lysozyme, lactic acid and glycopeptides isolated from *Lactobacillus* spp. on udder health parameters. A total of 10 cows with subclinical mastitis were used in the study – 5 cows (19 udder quarters) in the experimental group and 5 other cows (19 udder quarters) in the control group. The experimental cows received intramammary infusions of LLG, given once per day, 3 times with the intervals of 48 h. Cows from the control group received infusions of sterile 0.15 M NaCl, given in the same way as the treated cows. The following parameters were measured: somatic cell count (SCC), the total number of blood leucocyte, differentiation between banded neutrophils, segmented neutrophils and lymphocytes, peripheral blood mononuclear cells and markers of cell activation. Besides bacteriological culturing was performed. Quarter milk and blood samples were taken several times from the 1st to the 21st day. During the treatment the number of lymphocytes and T helper cells significantly decreased in the blood of the treated group, the CD8+ cells did not change remarkably, the number of CD25+, CD38+, as well as CD69+ and CD95+ cells had diminished during the treatment. On the 21st day a rapid increase of IL-2 receptor bearing cells was detected. A significant elevation of SCC in the treated group was observed but pathogenic bacteria incidence decreased.

**Key words:** subclinical mastitis; immunomodulation; somatic cell count, lymphocyte subpopulations.

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## Usage of multi-sensory MESH networks in monitoring the welfare of livestock

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**Abstract.** The trend of monitoring the welfare of livestock is continually developing at the moment. This monitoring leads to the optimization of the needs of livestock, which improves their final outputs. In terms of dairy cows, improvements in their living conditions may have a considerable impact on their productivity and the quality of their milk. Countless indicators such as temperature, humidity, how often they drink or eat, and many other parameters can be monitored. Specific measurements always depend on an initial hypothesis that is determined on the basis of specific problems. The main question still remains regarding how to measure selected variables, particularly how to transfer these outputs so that they can be easily processed. It is this issue that leads to the use of MASH multi-sensory networks.

**Key words:** MESH network, welfare, livestock, sensor networks, transmitter, IQRF, nod.

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## Livestock monitoring system using bluetooth technology

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**Abstract.** There is currently no inexpensive solution for monitoring theft of livestock. The cheapest way is to use a camera system. Whilst camera systems are able to capture theft attempts, in order to be truly effective it is necessary to permanently have a live operator available at the monitor to make evaluations. The aim was to therefore devise a system that would be used and that could identify the loss of an animal (or determine the specific animal that went missing). ‘Bluetooth Beacons’ were chosen after a detailed study of current technology. After closer inspection of this technology, we came to the conclusion that it is useful for this purpose with minimal cost for its application. This article would like to present concept of the method to monitoring livestock position.

**Key words:** ISM bands, Bluetooth Low Energy, iBacons, transmission, livestock.

**ACKNOWLEDGEMENTS.** It is a project supported by the CULS IGA TF 2016 ‘The University Internal Grant Agency’ (2016:31170/1312/3113).

## Effect of construction shape and materials on indoor microclimatic conditions inside the cowsheds in dairy farms

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**Abstract.** The aim of this paper is to present the results of microclimatic research focused on the indoor conditions in cowsheds and milking parlours in two dairy farms. The attention is paid mainly to the construction and materials used for buildings, which can influence together with technological equipment and system of ventilation the microclimatic conditions inside the cowsheds. In the frame of this research main parameters of internal and external properties of climate (air temperature, humidity, globe temperature, THI, BGHI and concentration of CO<sub>2</sub>) during the hot summer were measured and evaluated. Results of long time and short time measurements show very important role of used materials and shape of buildings. The research results show that the use of principles of passive air conditioning can contribute significantly to the improvement of internal microclimate. Reduced amplitude of temperature oscillation was 42.4% of amplitude of outside air temperature in cowshed with massive construction and 91.7% in modern light building. The average phase shift of temperature oscillations, expressed as a time delay of internal temperature rise behind the external temperature rise was about 2.8 hours and time delay of drop of internal temperature behind external temperatures drop was 3.3 hours in massive cowshed. The same parameters in modern light cowshed were only 1.1 hours and 0.5 hours.

**Key words:** air temperature, massive construction, solar radiation, temperature oscillations.

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## Effect of different air velocities on convective thin-layer drying of alfalfa for livestock feeding

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**Abstract.** Alfalfa (*Medicago sativa*) is widely used as forage which has very high feeding value. The aim of this paper is to inform about the experimental and theoretical investigations of alfalfa drying in thin layer. Special device for convection drying with air flow passing through material from bottom through supporting trays with sieve by constant temperature was used for drying when air velocity was  $0.7 \text{ m s}^{-1}$ ,  $1 \text{ m s}^{-1}$ ,  $1.2 \text{ m s}^{-1}$  and  $2.0 \text{ m s}^{-1}$ . The results were compared with natural convection drying by the same temperature, but with the  $0 \text{ m s}^{-1}$  air velocity. The increased air velocity for convection influenced drying process positively. The results show that the differences between the drying with air velocities  $1.2 \text{ m s}^{-1}$  and  $2 \text{ m s}^{-1}$  are very small, therefore  $1.2 \text{ m s}^{-1}$  could be realised as an optimum. The evaluation of measurement results was focused on curves of drying rate, changes in water content and changes of moisture depending on the time and their mutual relations. Experimental data create the background for calculation of main parameters useful for description and modelling of the drying process, which can be helpful e.g. for decision of optimum drying time. Drying alfalfa for hay by forced convection shortened the drying time as compared with natural convection two and a half times. Drying alfalfa for haylage by forced convection shortened the drying time as compared with natural convection even four times.

**Key words:** air, drying time, forced drying, moisture, natural drying.



## Determination of poultry house indoor heating and cooling days using degree-day method

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**Abstract.** In poultry production, degree-day values are used as fundamental design parameters considered among others in determining the extent of heating and cooling of poultry housing. In this study, heating and cooling data values for each of broiler production period were determined using the degree-day method. The total length of the experiment was 123 days which corresponds to 3 growing periods. The inside and outside air temperatures of the poultry house were measured using air temperature data loggers positioned at different points and heights within and outside broiler house. Knowledge of heating and cooling day values is important as it necessitates the provision and maintenance of ideal bird's production conditions and ensuring the economic viability of the enterprise through optimized energy consumption.

**Key words:** Broiler, energy, production period, temperature.

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## The prevention of harmful gases and odours dispersion by biofiltration in the animal farm

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**Abstract.** Animal farms are have to be controlled regarding to environmental issues beacuse of their waste's effects. Dispersion of harmful gases and odour is some most important effect of animal waste. Decomposition of animal waste may cause dispersion of harmful gases such as ammonia, methane, carbon dioxide, hydrogen sulfide etc. and odours. Harmful gases and odours impact on human and animal welfare negatively. Biofiltration is a technique used to prevent the dispersion of harmful gases and odour on animal farms. Especially some animal production types such as swine and poultry farms may cause great problem in terms of harmful gases and odour, so biofiltration has been seen as an effective method treating polluted air in these farms. The process of biofiltration is conducted based on biological degradation of pollutants. The bed materials such as litter, mulch and woodchips etc. are used in biofiltration to ensure microbiological environment. In this study, it was purposed to give information about the biofiltration, its basic principles and usage on animal farms based on conducted researches.

**Key words:** animal waste, biofilters, treatment, environmental problems.

## Evaluating thermal performance of experimental building solutions designed for livestock housing: the effect of greenery systems

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**Abstract.** The thermal performance of a greenhouse-type building provided with a living plant canopy was evaluated in Northern Italy during summer. Four reduced scale buildings with different types of covering were tested. The first type was the reproduction of a gable roof covered with 40 mm-thick sandwich panels (SAND), a widespread solution for dairy barns in temperate climates, used as control. Two roofs were reproductions of a Venlo-type greenhouse covered with a 0.2 mm-thick transparent EVA film equipped with either a reflective shading screen with 70% shading level (TRA+SHA) or with a living plant canopy (TRA+PLA). The last type of roof consisted of the living plant canopy alone (PLA). Plant canopies were made up of climbing plants (*Trachelospermum jasminoides*) with an average LAI of 1.39 m<sup>2</sup> m<sup>-2</sup>.

Data were analysed with mixed linear models for repeated measures. Fixed effects tested were roof type and the interaction of roof type and time of the day. Internal temperature in TRA+SHA (22.60 °C) was higher than PLA (21.28 °C;  $p > 0.001$ ), SAND (21.53 °C;  $p = 0.026$ ) and TRA+PLA (21.68 °C;  $p = 0.036$ ), with no significant differences among the latter three. Differences were larger during the hottest hours of the day (from 09:00 till 17:00) while, during the night, internal temperature did not differ among types of roof.

Results indicate that greenhouse-type buildings with conventional shading systems may not be adequate for housing livestock in warm climates. However, the employment of greenery systems such as a plant canopy may effectively reduce internal temperature. Further research is deserved to develop suitable building solution for livestock farming.

**Key words:** livestock housing, greenhouse, green roof, greenery systems, thermal performance.

## Peas and Beans as a Protein Feed for Dairy Cows

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**Abstract.** The need for alternative protein sources to soybean meal, partially or fully substituted in the diets of dairy cows, is an urgent problem in farming nowadays. Soybean meal is the most common protein source included in feed concentrate for dairy cows in Latvia and in other European countries as well. Among possible alternatives, grain legumes seem interesting for dairy cow diets because of their rapid degradation in the rumen and readily available energy. Peas and beans will be an important source of proteins in feed. Biochemical tests were done on eight samples of domestically grown dried peas of average size, 11 samples of dried beans of average size and some samples of soybean meal to examine the chemical composition of the peas and beans. Peas and beans were included in the feed ration during a feeding trial on dairy cows. Milk yields and milk quality parameters were examined in the trial. The digestibility of peas of most varieties and breeding lines examined was considerably higher than that of soybean meal, while the digestibility of beans of all the varieties and breeding lines examined and of soybean meal was the same. The peas contained more reducing sugars, starches and had a higher value of NEL than the tested beans, which meant the peas had a higher nutritional value. The diets comprising beans and peas fed to the dairy cows increased the fat and protein contents of milk, compared with the control group and the beginning of the trial. The total amount of amino acids increased in the bulk milk samples of all the trial groups during the feeding trial.

**Key words:** peas, beans, dairy cows, nutritional value, productivity, milk quality.

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## Comparison between feed microscopy and chemical methods for determining of crude protein and crude fiber content of commercial mixed feeds

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**Abstract.** The use of chemical methods in the determination of protein content in feed raw materials is time consuming and costly. The aim of this study to determine the amount of crude protein and crude fiber in mixed feeds using methods feed microscopy and chemical methods. Cattle feed, cattle milk feed, lamb raising feed, and meat chick feed have been used to study mixed feeds. By determining the results to indicate that feeds microscopy method approximately how much closer to chemical methods. The percentages of raw materials of crude protein and crude fiber in mixed feeds were determined with stereo microscopy and compared with obtained results of chemical methods. As a result there is no statistically difference in crude protein between feed microscopy method and chemical method. Feed microscopy estimating method can be used instead of chemical methods for crude protein analysis. Also, there is an important difference ( $P < 0.01$ ) between two methods for crude fiber analysis, so that it is determined that feed microscopy method cannot be used instead of chemical method. As a result, feed microscopy method can be suggested because crude protein content in raw materials of feed is more economical and shorter than chemical method.

**Key words:** Feed microscopy, chemical method, crude protein, crude fiber.

## Sand losses out the pens in barn with free-stall housing system

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**Abstract.** Proper sand management can be a critical aspect in the selection and successful use of sand as a bedding material for dairy cows. In many regions and countries, use of sand as a bedding material is considered as a useful alternative solution in dairy farms, where non-organic matter can serve as an equivalent of straw and other organic materials, e.g. sawdust. Assessment of sand management in the barn with dairy cows involves numerous problems, such as sand consumption, frequency of filling in the sand, quality of sand, as well as cows' response to comfort conditions created by lying stalls covered with sand. This paper presents results of some investigations concerning sand losses in the barn with dairy cows. In practice, sand consumption is a result of natural occurrences, when cows leave lying stalls. Moreover, part of sand, together with faeces, is taken out of the stall when the lying area is handled by persons responsible for cleanliness and hygiene in the stall. This paper indicates, based on the authors' own observations and investigations, that an improper construction of lying stalls can result in the increased losses of the sand in the barn, which translates into financial losses. In addition, a number of methods of measurement, together with the details of the structure of sand losses in the barn with a free-stall housing system, were presented. The discussion develops the issue of effective use of sand as a bedding material in the barn with dairy cows, including the need to use technical equipment in order to keep the barn floors clean and ensure the cows' comfort.

**Key words:** bedding, cow, dairy farm, free-stall, keeping system, management, sand.

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## Monitoring of ammonium pollution from dairy cows farm according of urea content in milk

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**Abstract.** The objective of this study was to evaluation of urea content in milk to assess the potential of ammonia pollution from farms. Dairy cows in farms were located in different Latvia region with different holding system. Research was conducted under production conditions in four different agricultural holdings located in various places of Latvia and represent different animal housing and feeding technologies. Monthly together with herd control was recorded milk yield and take milk samples was analysed for fat, total protein and lactose (%), urea content ( $\text{mg dL}^{-1}$ ) and somatic cell count (SCC). Milk content parameters for total 14,873 milk samples were analysed in accredited milk quality laboratory. The statistical analyses were performed with the SPSS program package. The results acquired show that in three farms (A, B and D) urea content in 59–71% of milk samples comprised 15.1–30.0  $\text{mg dL}^{-1}$ . However, also in these holdings urea content in 29–41% of samples was below or above the optimum threshold. Unpleasant situation was observed in holding C; there urea content only in 16% of milk samples was within the optimum limits. Calculations of forecasted ammonium pollution emitted daily from agricultural holdings using tie stall housing may comprise 91.4–104.0 g from cow, while amount emitted by freestall holdings using housing may constitute 93.9–95.9 g from cow daily. By using these data, each farm may make calculations and forecast farming efficiency and environmental threats.

**Key words:** milk urea nitrogen, holding system.

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## Method for selection of pig manure processing technologies

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**Abstract.** The criteria, which take into account both economic and environmental indicators, were suggested for assessment of technologies and selection of the most reasonable solution. The method of Pareto optimization was applied. Technologies suited for the North-West Russia were considered to design a mathematical model and to obtain the required indicators for the criteria calculation. The technology of multi-stage processing of pig manure with cyclic sedimentation tanks was studied in more detail based on a separate, specially designed three-level mathematical model. The objective function was the eco-economic index of nitrogen, which is the ratio between the economic benefit from the marketed yield increment and the costs of nutrients retention in the organic fertilizers applied to soil under the harvested crop yield. The resulting simulation data were substantiated by experimental studies. A mathematical model and an algorithm for selecting the best-suited technology were designed. As the calculation process involved a large bulk of data, the WEB programming was used. Simulation results demonstrated 90% accurate choice of technology. The designed model was tested for the conditions of a pig complex in Leningrad Region with the manure output of 150 t per day and no own farmland for organic fertilizer application. Calculations proved the economic and ecological effectiveness of the multi-stage processing of pig manure: operating costs per one ton of produced organic fertilizer were reduced 1.8 times, fuel costs – 1.4 times and labour costs – 3.3 times. The chosen technology also featured higher ecological safety coefficient. Estimated ecological and economic effect of introduction of this technology amounted to 5936 thousand roubles per year.

**Key words:** manure management, processing method, algorithm, mathematical model, pig farm.



## Reticulo-ruminal pH and temperature relationship between dairy cow productivity and milk composition

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**Abstract.** The aim of the research was to establish interrelations between reticulo-ruminal pH and temperature, cows' productivity and milk composition (milk fat, protein, lactose, somatic cell count and electrical conductivity of milk) by using specific *SmaXtec* reticulo-ruminal boluses. In the research were included four different age dairy cows in early lactation period. The reticulo-ruminal pH and temperature was measured every 600 sec. over a 79 day period. The milk yield and quality was registered three times per day with automated data recording and management system *Afmilk*. Results showed that reticulo-ruminal temperature brightly demonstrates cow drinking behaviour and did not influence any of the investigated milk parameters. There was established a weak, statistically significant correlation between reticulo-ruminal pH and energetically corrected milk ( $r = 0.19$ ;  $P < 0.01$ ), milk protein level ( $r = 0.35$ ) and a weak negative correlation between milk fat/protein ratio ( $r = -0.22$ ;  $P < 0.01$ ). No relation between reticulo-ruminal pH, milk somatic cell count and milk electroconductivity was observed. Reticulo-ruminal pH fluctuations were at individual ranges for each cow without affecting an individual milk fat/protein ratio despite all of them received the same ration. It seems that milk fat/protein ratio is primarily dependent on the feed composition and properties. In the study was included one cow whose reticulo-ruminal pH was decreased below 5.7 for 400 min. in a day, and it had not had any individual effect on milk fat/protein ratio. That fact indicates to an individual cow tolerance to subacute rumen acidosis.

**Key words:** reticulo-ruminal pH, reticulo-ruminal temperature, milk composition, productivity.

## The effect of bedding amount on gas emissions from manure during storage

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**Abstract.** One of the major agricultural pollutants of environment is manure from livestock. We focused on dairy cows kept in the barns with straw bedding commonly used in the Czech Republic. We tested the hypothesis that the amount of bedding used daily relative to the number and size of animals kept has a significant effect on the emissions of gases from manure stored in a manure pile. In the experiment, a group of 10 dairy cows of Holstein and Czech Red Pied breed was housed in a stable bedded with various amounts of wheat straw (4–10 kg/livestock unit per day). The manure was removed from the stable after 48 h and mixed was stored in cubic containers with drain floor allowing measurement of manure leachate release. For 50 days we measured weight, volume, weight of manure leachate and manure temperature. Decreasing stored manure weight can be attributed to release of manure leachate and emissions of gases, primarily water vapor, as a result of microbial activity and increased temperature in the manure during storage. Using the calculated model, we found that daily production of emissions of water vapor and other gases was related to bedding amount in a statistically significant manner ( $P < 0.001$ ). The cumulative amount of gas emissions grew rapidly in all treatments. Also total amount of emissions was related to bedding amount in a statistically significant manner ( $P = 0.004$ ). We also found the relationship between internal manure temperature and the logarithm of the amount of emissions produced to be statistically significant ( $P < 0.001$ ).

**Key words:** dairy cows, manure storage, bedding amount, gas emissions

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## Effects of compaction pressure on silage fermentation in bunker silo

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**Abstract.** The aim of this research was to determine the effects of compaction pressure on maize silage fermentation under field conditions. The CAT 955 L type work machine was used for the compaction of the material. In this research, a pressure measurement system was developed to measure the compaction pressure in bunker silos. In bunker silos, 24 points for pressure and temperature measurement were identified. Chemical and microbiological analyzes were made by taking samples from each measurement point. The lowest temperature is measured in the back wall of the silo. There is a significant relationship between pressure and temperature. Pressure had a significant effect ( $P < 0.05$ ) on silage fermentation. There was a significant correlation between regions in bunker silo and pressure ( $R^2 = 0.914$ ,  $P < 0.01$ ).

**Key words:** Silage, pressure, compaction, bunker silo, pressure measure method.

**ACKNOWLEDGEMENTS.** This research was supported by the Namık Kemal University (NKUBAP-422), Turkey.

## Effect of altitude and vacuum pressure on flow rate of vacuum pumps on milking machines driven by gasoline engine and a generator

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**Abstract.** The objective of this study was to compare the performances of two vacuum pumps driven by an internal combustion (gasoline) engine (Vacuum Pump 1) and a generator powered electrical motor (Vacuum Pump 2) under different altitude and vacuum pressures. The vacuum pumps delivering a flow rate of 350 l min<sup>-1</sup> at 50 kPa vacuum pressure were tested, which are commonly used in bucket type milking machines. Atmospheric pressures, maximum vacuum pump pressures, and air flow rates at milking pressures (38–50 kPa) were measured at altitudes from 0 to 2,000 m with 200 m increments. Maximum pump pressure reduced by 3.8, 11.3, and 19.9% for Vacuum Pump 1 at altitudes of 400, 1,200, and 2,000 m, respectively whereas Vacuum Pump 2 had 4.4, 12.3, and 20.4% less maximum pressure at the same altitudes. Air flow rate (457.7 l min<sup>-1</sup>) of Vacuum Pump 1 at the sea level at 38 kPa working pressure reduced by 22.7% at the altitude of 2,000 m. The air flow rate reduced more (28.1%) at the operating pressure of 50 kPa for Vacuum Pump 1 at 2,000 m, compared to the sea level. Similarly, for Vacuum Pump 2, the measured flow rate at 38 kPa showed 19.1% reduction at 2,000 m while at 50 kPa the air flow rate reduced 26.4%, corresponding to 352.3 l min<sup>-1</sup>. Differences in the air flow rates of vacuum pumps 1 and 2 under different vacuum pressures were insignificant ( $P > 0.05$ ). However, the effect of altitude and vacuum pressure on measured air flow rates was significant for each pump at 5% level. The regression equations were also obtained for atmospheric pressure-altitude, maximum pump pressure-altitude, air flow rate-altitude, and air flow rate-pump vacuum-altitude. High determination coefficients that were found for these relationships suggest that pressure setting can be accurately done as the altitude at which milking needs to be changed without suffering from air flow rate during milking with bucket type machines.

**Key words:** Milking machine, vacuum pump, gasoline engine, generator, altitude, pump pressure, air flow rate.

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## Disinfection of solid fraction of cattle manure in drum-type bio-fermenter

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**Abstract.** In the context of increased intensification of production and disruption of established ties between livestock and crop farms there is an urgent need to introduce novel, more efficient, economically viable and environmentally sound techniques of animal and poultry manure processing. As a part of the ongoing work on implementation of best available techniques (BAT) in various sectors of Russian economy, agriculture included, the bioconversion technology of organic waste in a drum-type bio-fermenter was considered as one of BAT candidates, which is most adapted to the natural and climatic conditions of North-West Russia and feature the minimal environmental impact. The main purpose was to investigate the influence of bioconversion of solid fraction of cattle manure on selected microbial parameters and parasitic purity in the raw material, semi-finished and final products. The study was conducted in the IEEP Organic Waste Bioconversion Laboratory on a patented drum-type bio-fermenter. After 18 hours the digested material self-heated to 55 °C, i.e. the lower limit of the range of thermophilic microbial activity. By the 30<sup>th</sup> hour after the experiment started the temperature had reached the maximum level of 71 °C, then it dropped to 62–66 °C and stabilized in this range. 48 hours after the temperature reached 55 °C, the content of coliform bacteria reduced to acceptable limits, and that of *Enterococcus* dropped more than 10 times. After 120 hours the digested product was completely disinfected.

**Key words:** cattle manure, disinfection, biofermentation, microbial parameters, parasitic purity.

## **VI PRECISION AGRICULTURE**

## Investigations about the impact of the sowing time and rate of the biomass yield and quality of industrial hemp

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**Abstract.** The aim of this study was to find the optimum sowing rate of industrial hemp (*Cannabis sativa* L.) and to clarify the impact of the sowing rate on the production of biofuel from hemp biomass in Latvia. Field trials were carried out at the Research and Study Farm 'Pēterlauki' of the Latvia University of Agriculture in 2012–2014. The industrial hemp (*Cannabis sativa* L.) 'Futura 75' was sown in a Luvic Endogleyic Stagnosol soil: pHKCl 6.7; P – 52 mg kg<sup>-1</sup>; K – 128 mg kg<sup>-1</sup>; the organic matter content – 21–25 g kg<sup>-1</sup>. Hemp was sown in 10-m<sup>2</sup> plots, triplicate, on May 8 and 17. The total sowing rate was 20 (100), 30 (150), 40 (200), 50 (250), 60 (300), 70 (350), 80 (400), 90 (450), and 100 (500) kg ha<sup>-1</sup> (germinating seeds per 1 m<sup>2</sup>). The plots were fertilised as follows: N – 120 kg ha<sup>-1</sup>; P<sub>2</sub>O<sub>5</sub> – 80 kg ha<sup>-1</sup>; and K<sub>2</sub>O – 112 kg ha<sup>-1</sup>. Hemp was harvested when the first matured seeds appeared. The biometrical indices (height and stem diameter), harvesting time, the amount of fresh and dry biomass, and the fibre content were evaluated. Depending on the sowing rate, the yield of dry matter was on average 9.2–12.1 t ha<sup>-1</sup> when hemp was sown at the beginning of May, and 7.9–10.0 t ha<sup>-1</sup> when hemp was sown in the middle of May.

**Key words:** industrial hemp, sowing time and rate, yield, quality.

## Energy balance of sunflower production

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**Abstract.** The aim of the present study was to make an energy analysis of sunflower crop in the Trakya Region of Turkey, to evaluate the potential for using it as bioenergy source. Actual data for the common cropping practices applied in the region were collected with questionnaires given to the farmers. Literature data were used to obtain necessary energy indices. The collected information was used to establish energy budgets. Two alternative scenarios were examined: 1<sup>st</sup>-Using only the seed for biofuel production and 2<sup>nd</sup>-using the seed for biofuel and the stalks as biomass for bioenergy. The results showed that sunflower presented positive energy balance for both cases. Net energy was 35,334 MJ ha<sup>-1</sup> when only the seed was taken into account and 87,308 MJ ha<sup>-1</sup> for both seed and stalks. Energy efficiency was 3.67 and 7.34 respectively. Fertilization was the most energy intensive input (6,594 MJ ha<sup>-1</sup>) accounting for 48-50% of the total inputs. Tillage was the second most energy intensive input (3,595 MJ ha<sup>-1</sup>) accounting for 26-27% of total inputs. There were 6 different tillage operations such as ploughing, 4 machinery passages for seedbed preparation and hoeing in the sunflower production. All these operations increased energy inputs of the tillage. The total energy inputs were relatively low because it was possible to achieve high yields without irrigation.

**Key words:** sunflower, energy analysis, Trakya Region



## Comparison of iodine application methods in Rocket Plant

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**Abstract.** Iodine is an essential trace element for human health and is involved in the production of the thyroid hormone. Recently, a new idea has emerged: to meet people's need for daily iodine by increasing the iodine content of vegetables with high iodine bioavailability and assimilation. This study was carried out with iodine foliar application and root application methods to determine which is more appropriate when attempting to increase iodine content. An experiment was conducted in a greenhouse with 4 doses of iodine in the form of potassium iodide (0, 2, 4, 8 mM), two application methods (foliar and root application) and three replicates. At the end of the experiment, the plants' fresh and dry weight, relative water content, membrane stability, chlorophyll a, chlorophyll b and total chlorophyll were determined. The results were subjected to analysis of variance according to the randomized blocks experiment design using the MINITAB 17.0 statistical package program. The applications did not show a statistical difference in plant fresh weight and dry weight. There was no statistical difference in the relative water content between the applications, while a statistical difference ( $P < 0.05$ ) in the membrane stability was observed for the interaction of application type and application dose. Chlorophyll a, chlorophyll b and the total chlorophyll amount were also statistically affected ( $P < 0.05$ ) by the application doses. Foliar and root application methods have not caused significant loss of yield. Both methods are also considered to be appropriate to use in practice.

**Key words:** Iodine, Rocket, Vegetable, Thyroid.

## Sustainable land use management and guide for GIS-based decision support system

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**Abstract:** Decision Support System (DSS) provides a custom, flexible and dedicated management system, to assist managers, decision makers and policy makers in: provide timely, transparent, well informed and reproducible answers to important questions, quickly and effectively land use planning, reduce time and cost requirements transform data and information into knowledge and produce understandable results and decisions. Typical DSS interactive and integrated components are data and information management, analysis and modelling and scenario management and alternative formulation. GIS-Based Web Software was developed to supply the Corine Land Cover 1990-2000-2006-2012 data, to present the results of the models created within the scope of Integrated Land Use Management Modelling of Black Sea Estuarie ILMM-BSE Project BlackSea project and to make spatial analyses using geographic data. Application is comprises of two parts. One of them is GIS services that present the data and the other one is GIS interface that use for monitoring of the presented data and make analyses. Land-use management of estuaries/deltas areas is a multi-component and multidisciplinary process that requires more than a single method for successful results. Thus, an integrated GIS-based analysis system was developed in this project for a more efficient and scientific management of such areas from a holistic point of view.

**Keywords:** Decision Support System (DSS), CORINE, GIS-Based Web, Turkey.

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## Fungicidal activity of ultradisperse humic sapropel suspensions

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**Abstract.** The study compared the effect of two ultradisperse humic sapropel suspensions (UDHSS), obtained in Seryodka deposit (Pskov region, Russia), on viability of *Aspergillus niger* in four experiments. In Experiment 1, *Aspergillus niger* strain L-4 conidia with titre  $(3.1-3.7) \times 10^3$  CFU cm<sup>-3</sup> were suspended in 0.1 cm<sup>3</sup>, 1.0 cm<sup>3</sup>, 2.0 cm<sup>3</sup>, 3.0 cm<sup>3</sup>, or 5.0 cm<sup>3</sup> of either UDHSS, and immediately incubated on wort agar. In Experiments 2 and 3, *Aspergillus niger* L-4 conidia with the same titre were suspended in and remained in contact with 0.1 cm<sup>3</sup>, 1.0 cm<sup>3</sup>, 2.0 cm<sup>3</sup>, 3.0 cm<sup>3</sup>, or 5.0 cm<sup>3</sup> of UDHSS for 2 or 24 hours at  $(20.5 \pm 0.5) ^\circ\text{C}$  ( $68.9 \pm 0.9^\circ\text{F}$ ) and incubated on wort agar. The number of colonies in Petri dishes upon 24 hours and 5 days of cultivation was observed. In Experiment 4, contamination of barley grain and distillers' dry grain (DDG) was simulated. DDG treated with 20 cm<sup>3</sup> kg<sup>-1</sup> of either suspension was inseminated with *Aspergillus niger* L-4 at  $(5.1-5.3) \times 10^3$  CFU cm<sup>-3</sup>, and put under standard storage conditions, changes of microflora examined at 24 hour intervals during 5 days. As a result of Experiment 1, in consideration to statistical significance, there was little fungicidal action on *Aspergillus* conidia. In Experiments 2 and 3, a prominent fungicidal effect was demonstrated by both sapropel suspensions. In Experiment 4, both types of suspensions exhibited a statistically significant effect on *Aspergillus* conidia only in samples previously remaining in contact with 3.0 or 5.0 cm<sup>3</sup> of suspension. Amplitude of the effect proved to be dependent on both UDHSS dosage and time of contact (2 or 24 hours).

**Key words:** *Aspergillus niger*, distillers' dry grain, ultradisperse sapropel suspensions, fungicidal activity.

## Energy balance in production of chickpea in Turkey: A study performed in Adıyaman Province

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**Abstract.** In this study, it has been aimed to form the energy balance in the production of chickpea (*Cicer arietinum* L.) in Adıyaman province of Turkey. The material of the research consists of the chickpea enterprises in the center of Adıyaman province in the scope of the production season of 2015–2016. In this study, the number of enterprises for which is required to be made the study has been computed as 67 according to the simple random sampling method. Survey and observation studies have carried out in these designated enterprises. The energy equivalence of the chickpea samples taken from the enterprises has been determined by the calorimeter device. According to results of the study; the total energy input has been computed as 12,225.69 MJ ha<sup>-1</sup> and the total energy output has been computed as 31,527.52 MJ ha<sup>-1</sup>. The energy inputs in the production of chickpea have been 3,575.69 MJ ha<sup>-1</sup> (29.25%), 3,523.08 MJ ha<sup>-1</sup> (28.82%), 3,280.32 MJ ha<sup>-1</sup> (26.83%), 1,230.39 MJ ha<sup>-1</sup> (10.07%), 358.20 MJ ha<sup>-1</sup> (2.93%), 131.52 MJ ha<sup>-1</sup> (1.08%) and 126.50 MJ ha<sup>-1</sup> (1.03%) as fuel energy, chemical fertilizers energy, seed energy, machinery energy, farmyard manure energy, human labour energy and chemicals energy inputs, respectively. In this study, indicators showing the energy ratio, specific energy, energy productivity and net energy were determined as 2.58, 7.07 MJ kg<sup>-1</sup>, 0.14 kg MJ<sup>-1</sup> and 19,301.83 MJ ha<sup>-1</sup>, respectively. According to the results of the study, it is clear that chickpea production is an economical production for the 2015–2016 production seasons.

**Key words:** Adıyaman, chickpea, energy balance, specific energy, Turkey.

## Effect of Controlled Traffic Farming on Weed Occurrence

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**Abstract.** Soil compaction caused by field traffic is one of the most important yield limiting factors. Moreover, published results report that soil over-compaction inhibits the uptake of plant nutrients and decreases their ability to compete with weeds. Controlled Traffic Farming (CTF) is technology which prevents excessive soil compaction and minimizes compacted area to the least possible area of permanent traffic lines. A long-term experiment was established at University farm in Kolinany (Slovakia) in 2010 with 6 m OutTrack CTF system. Random Traffic Farming (RTF) is simulated by 1 annual machinery pass crossing the permanent traffic lines. Aim of presented study was to assess the effect of CTF on weed infection pressure. To achieve this, weed occurrence at different traffic treatments was determined. Emerged weeds per square meter were counted, identified and recorded at 14 monitoring points. Results showed that higher weed infection was found at the area with one machinery pass compared to the non-compacted area. Following weeds were identified: *Bromus secalinus* L., *Stellaria media* (L.) VILL., *Veronica persica* POIR. in LAMK., *Poa annua* L., *Polygonum aviculare* L., *Convolvulus arvensis* L. Occurrence of these weeds could be used as soil compaction indicator. Based on these results it can be concluded, that CTF technology has potential to decrease weed infestation in comparison to RTF system due to ration of non-compacted to compacted area. Moreover, with exact localization of weeds in traffic lines together with exact identification of weed species, it is possible to target the application of herbicides.

**Key words:** Controlled Traffic Farming, soil compaction, weed infection

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The authors are grateful to staff at the University Farm in Kolinany (Slovakia) for technical and operational support to conduct this research.

## **Impact of the seeding and nitrogen fertilizer rates of spring wheat that is used as a cover crop on the yielding ability of tetraploid red clover stand established at different seeding rates**

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**Abstract.** In the years 2013–2014, a field trial was conducted at the Estonian Crop Research Institute in order to investigate a possibility of using spring wheat as a cover crop in the establishment of red clover seed field. In the trial the cover crop had four different seeding and fertilization rates. Two tetraploid red clover cultivars, 'Varte' (early) and 'Ilte' (late), were seeded at rates 2, 4, 6 and 8 kg PLS per hectare in four replications. In the year of sowing the height and density of generative tillers of spring wheat, the grain yield and its quality, the number of red clover plants per m<sup>2</sup>, and the seed yield of red clover and its quality in the 1<sup>st</sup> year of harvest were determined. Economic feasibility was calculated based on the prices valid at the time of trial conduction. The trial confirmed that while establishing a red clover seed field, it is possible to replace the earlier recommended six-rowed early barley cultivars with early spring wheat cultivars. It is expedient to reduce the seeding rate and nitrogen fertilizer rate of cover crop by one third. The optimum seeding rate of tetraploid red clover cultivars was 4–6 kg PLS ha<sup>-1</sup>.

**Keywords:** cover crop, seeding and fertilization rates of cover crop, tetraploid red clover, seeding rate, seed yield, economic feasibility.

**ACKNOWLEDGEMENTS.** The research work was carried out in the framework of an applied research project ordered and financed by the Ministry of Agriculture of the Republic of Estonia.

## The influence of agricultural traffic on soil infiltration rates

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**Abstract.** The objective of the study was to investigate the effect of agricultural machinery passes on soil infiltration rate. The experiment was conducted in a large covered area (Soil Hall) with the sandy loam soil type. Four compactions levels were applied: control, one, two and three tractor passes.

The infiltration measurements were conducted using two methods: Simplified Falling–Head (SFH) and Mini Disk (MD). The other supporting measurements were disturbed soil samples and cone index measurements.

Based on the SFH method it was observed that as the number of passes increased from 0 to 3 the infiltration rate decreased. The MD results also decreased with the increase in the number of passes. The bulk densities (at 0–0.07 m depth) increased with the number of tractor passes, under the conditions of soil gravimetric moisture content ranging between 14 and 18% vol. The cone index values at the depth of 0–0.05 m increased with the number of passes.

When comparing the results obtained using the MD and SFH, a strong relationship was not found. It could be concluded that the SFH method might be more robust and appropriate for determining the effect of the number of tractor passes on the soil water infiltration in these conditions.

**Key words:** cone index, infiltration rate, soil compaction.

## Assessment of the relationship between spectral indices from satellite remote sensing and winter oilseed rape yield

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**Abstract.** Winter oilseed rape (*Brassica napus* L.) belongs among the most common and strategic crops in the Czech Republic. Growth and vitality status, yield potential and yield prediction of oilseed rape on plots of different sizes can be effectively examined using remote sensing. That is why the main aim of this study was to discuss a possibility of deriving spectral indices for an assessment which spectral index is more adequate to forecast oilseed winter rape development and consequent yield in the Czech Republic. Information about the winter oilseed rape growth and yield was collected in three years – 2004, 2008, 2012. A relationship between grown crops and selected vegetation indices was evaluated. The Landsat 7 satellite images were selected as a source for deriving spectral indices. The relationship between each spectral index and yield was analysed in 2012 only. Five images on different dates during the whole life of winter oilseed rape were found during this year. The images from the years 2004 and 2008 were cloudier. The spectral indices showing the best relationship with yield from 2012 were then analysed in the images from 2004 and 2008. The results showed that Enhanced Moisture Stress Index is the most acceptable index from the selected indices used in this study. From an agronomical point of view no available index was found to be suitable for the winter rape growth evaluation due to dependence on precipitation conditions. For monitoring of the yield components in winter oilseed rape in conditions of the Czech Republic, it seems necessary to develop a new vegetation index which will reliably describe the winter oilseed rape growth stages during the whole vegetation season.

**Key words:** Remote sensing, spectral indices, winter oilseed rape, yield rating, Landsat 7 images.



## Agricultural field production in an “Industry 4.0.” concept

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**Abstract.** Precision Agriculture is a well-established concept in agricultural field production. It has developed over the last 3 decades. With this concept, farmers are used to collect, and handle data. Farmers are also used to create solutions for field operations based on knowledge of diversity and local data. Compared to classical industrial production agricultural field operations interacts with a biological active system. From a production management system point of view the industrial production takes place in close well defined environments, where performance data to a big extend can be measured by deterministic matters: mass (kg), Volume/dimensions (m<sup>3</sup>/m), time (sec). etc.

In agricultural operations as tillage, seeding, fertilising and plant care, there are by nature many possible adjustments available to optimise the operation method, -intensity and -timing. The problem here is to establish the knowledge necessary to support the control of the individual, precision based operation. In this environment parameters as for example the workability of the soil cannot be defined in terms of few deterministic parameters. Neither the operation impact from the tool to the soil. This challenge is one of the reason why the concept of precision agriculture still covers big unutilised potentials. It is the hypothesis for this article to analyse, if inspiration for the concept of “Industry 4.0” can facilitate the establishment of operational solutions in the field of precision farming.

**Key words:** Precision farming, Industry 4.0., precision tillage, spot spraying.

## The effects of different nitrogen doses and irrigation levels on yield and plant water consumption of silage corn

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**Abstract.** The present study was conducted to investigate the effects of different irrigation levels and nitrogen doses on yield and plant water consumption of silage corn. Three different irrigation levels (I50: 50, I75: 75 and I100: 100% of field capacity) and 3 different nitrogen doses (N10: 10, N20: 20 and N30: 30 kg da<sup>-1</sup>) were applied to silage corn. Experiments were implemented in split-split plots design with three replications during the growing seasons of 2014. Irrigation treatments were placed over main plots and nitrogen doses were placed over sub-plots. Water x nitrogen interaction was not found to be significant. Increasing nitrogen doses increased green herbage yield. Green herbage yields varied between 5790-8250 kg da<sup>-1</sup> in irrigation treatment and 5130-7630 kg da<sup>-1</sup> in nitrogen treatment. The amount of applied irrigation water varied 753, 565 and 377 mm respectively. The plant water consumption was found 896, 718 and 528 mm respectively.

**Key words:** Corn, herbage yield, irrigation, nitrogen, plant water consumption.

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## Nutrient status of the American cranberry in Latvia (2005–2016)

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**Abstract.** The American cranberry (*Vaccinium macrocarpon* Aiton) is an evergreen groundcover plant native to North America. Nowadays cranberries are successfully cultivated in Latvia with total plantings of more than 125 ha. Being a native wetland plant, cranberries are considered as nutrients low requiring crop, however, balanced mineral nutrition is one of the key factors that determine plant growth and yield development. Surveys were carried out to determine the actual status and trends in mineral nutrition of American cranberries in Latvia during 2005–2016. Together 190 plant samples were collected from different cranberry producing sites in Latvia over 3 periods: 2005–2007, 2008–2011 and 2012–2016. Cranberry tissue analyses were used as diagnostics method to control plant nutrient (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Mo, B) status. The obtained results revealed notable nutrient imbalance in the years of the study. In general, our results suggest that only about 50% of plant tissue nutrient indices were in the sufficient range. Deficiency of N P, S, Fe, Cu, and Mo, and high levels of Mn was found in the majority of samples analyzed. In general, diverse tendencies were stated for the nutrient supply of cranberries from 2005 to 2016: positive trend in nutrient status of cranberry crop were found for N, K, Ca, while mean concentrations of S, Fe and Mo, as well as frequency of optimal indices decreased. The small count of nutrient indices in high till toxic range suggested on environmentally sound way of cranberry fertilization practices in Latvia.

**Key words:** *Vaccinium macrocarpon* A., plant analysis, mineral nutrition.

## Crop Coefficients for Pumpkin Seed Plants

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**Abstract.** This study was conducted to determine the crop coefficient ( $k_c$ ) and evapotranspiration rate ( $ET_c$ ) of pumpkin seed plants in order to schedule irrigation properly. Experiments were carried out during 2016 cropping season in Kayseri, Turkey in a completely randomized block design with 3 replications by using drip irrigation systems. Irrigation schedule was based on replenishment of 100, 80, 60, 40, 20, and 0% of soil water depleted from 60 cm soil depth. The amount of applied irrigation water was between 104 and 470 mm. The plant water consumption varied between 227 and 628 mm. The values of  $k_c$  for initial, mid-season and end-season period were determined as 0.19, 1.36 and 1.14, respectively. In addition, yield response factor ( $k_y$ ) of pumpkin seed was found as 0.90.

**Key words:** Pumpkin seed, crop coefficient, evapotranspiration.

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## Effects of irrigation applied at different growth stages on chickpea yield

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**Abstract.** This study was conducted over the experimental fields of Erciyes University in 2016 to investigate the effects of irrigations applied at different growth stages on chickpea yields. Experiments were conducted in randomized blocks design with 3 replications. There were 7 irrigation treatments as of I<sub>1</sub>: rainfed, I<sub>2</sub>: pre-bloom single irrigation, I<sub>3</sub>: single irrigation at the beginning of blooming, I<sub>4</sub>: single irrigation at 50% pod set, I<sub>5</sub>: two irrigations at 50% bloom and 50% pod-set, I<sub>6</sub>: two irrigations at pre-bloom and 50% pod-set, I<sub>7</sub>: full irrigation. The amount of applied irrigation water varied between 85.6 - 323 mm. Plant water consumptions varied between 262 - 569 mm. The greatest yield was obtained from I<sub>4</sub> treatment with 273 kg da<sup>-1</sup> and the lowest yield was obtained from I<sub>1</sub> treatments with 146 kg da<sup>-1</sup>. It was concluded for chickpea cultivation under deficit water resources conditions that water deficits may be applied at different growth stages except for 50% pod-set period.

**Key words:** Chickpea, irrigation, yield, ET

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## Strawberry Leaf Surface Temperature Dynamics Measured by Thermal Camera in Night Frost Conditions

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**Abstract.** Strawberry leaves surface temperature study was carried out at the commercial strawberry field in late autumn at a specific natural climatic situation, corresponding to night frost conditions. Thermal camera FLIR P660 with thermal sensitivity 30 mK and accuracy  $\pm 1$  K was used for obtaining 640×480 pixel thermal images and corresponding visual colour images of the strawberry leaves. The images were taken at ten-minute interval and analysed with FLIR ResearchIR Max software. The ambient air temperature, relative humidity, dew point, solar radiation and wind speed data were obtained by Davis Vantage Pro2 weather station. It was estimated that the surface temperature of the specific leaf is comparatively similar at different parts of the specimen and changes noticeably with the variation of solar radiation intensity. The speed of temperature changes was also analysed. During all the measurement period, the considerable difference between the temperature of the leaf and the ambient air temperature was established, especially in absence of solar radiation. The study showed that in night frost conditions the plants might be endangered by low temperatures even at the air temperatures above 0°C due to intensive energy loss by long wave radiation to the sky. It is suggested that the thermal imaging or infrared radiation measurement should be used simultaneously with air temperature measurements for more exact timing of night frost prevention measures at strawberry cultivation.

**Key words:** thermal imaging, surface temperature, strawberry leaf, night frost conditions, precision agriculture.

## Development and implementation of data collection technologies for digital mapping of soil electric conductivity

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**Abstract.** One of the main preconditions for the introduction of soil protection measures and sustainable use of a soil is to strengthen the knowledge base about the specific habitats characteristics with high spatial resolution and adequate interventions to these properties. One of the most common sensors used to describe the level of soil variability are devices that measure the electric conductivity of the soil.

Platform for the electrical conductivity measuring has been developed and implemented into the standard combined machines for the tillage and seeding, using an existing work tools as part of the platform. Within the field work the series of measurements was conducted with this machine and platform and data of electrical conductivity were collected. On the same field as a reference method electrical conductivity was measured by an electromagnetic induction probe EM38 MK2. Compared data from the measuring platform and the EM38 MK2 probe showed a high correlation value. The experiments demonstrate the possibilities of technical solutions of soil conductivity measurement implementation on tillage and seeding machines where by a modification of selected tillage and seeding machines together with incorporation of sensors directly onto the work tools is possible to obtain measuring platform that enables data collection directly during operation of the machine on the field.

**Key words:** Soil electric conductivity, soil mapping, soil sensor.

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## The content of weed seeds in the soil based on the management system

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**Abstract.** In 2008 an experiment was set up on the field in Eerika experimental station (Estonian University of Life Sciences) as a 5-field crop rotation: barley (*Hordeum vulgare* L.) with undersown red clover, red clover (*Trifolium pratense* L.), winter wheat (*Triticum aestivum* L.), pea (*Pisum sativum* L.), potato (*Solanum tuberosum* L.). The objective of the study was to measure the content of weed seeds in the soil and to evaluate the diversity of the species at the beginning of the period of organic production in 2011. In conventional farming systems without fertilizer (Con I) and conventional farming with mineral fertilizer (Con II) herbicides were used for weed control. All the crops in Con II system received P 25 kg ha<sup>-1</sup> and K 95 kg ha<sup>-1</sup>, but the application rates of mineral nitrogen fertilizer differed. In organic systems (Org I – organic farming based on winter cover crop and Org II - organic farming based on winter cover crop and manure), the winter cover crops (ryegrass after winter wheat, winter oilseed rape after pea, winter rye after potato) were sown after the harvest and were ploughed into the soil as green manure in spring. Organic farming systems (Org II) had a negative effect on the content of weed seeds in the soil (2.0–22.7% less seeds than in other variants). The seeds of *Chenopodium album* were the most abundant among summer annual weeds and the seeds of *Viola arvensis* among winter weeds in the soil. Organic farming measures increased the domination of *Chenopodium album* - the dominance index  $D'$  was increased by 0.09–0.14 compared to conventional variants. The content of seeds of winter weed *Viola arvensis* in Org II variant was decreased by 82%. The index of species evenness  $J'$  and Shannon Wiener diversity index  $H'$  were lower in organic plots by 0.10–0.18 and 0.60–0.19, respectively. Org II variants showed the best results based on the decrease of soil weed seed bank and distribution of the weed species.

**Key words:** organic farming, weed seeds, species diversity, evenness.

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## Fodder galega (*Galega orientalis* Lam) grass potential as a forage and bioenergy crop

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**Abstract** Fodder galega (*Galega orientalis* Lam.) is a forage legume that has been grown in Estonia for almost forty five years. Pure galega is known to be persistent, high-yielding crop and rich in nutrients, in particular crude protein (CP), neutral detergent fibre (NDF) and acid detergent fibre (ADF). Galega is usually grown in a mixture with grass in order to optimize its nutrient concentration, increase dry matter (DM) yield and improve fermentation properties. The trial plots were established on a typical soddy-calcareous soil. There are certain grass species suitable for the mixture. In this study galega mixtures with reed canary grass cv. 'Marathon', timothy cv. 'Tika', red fescue cv. 'Kauni' and festulolium cv. 'Hykor' were under investigation in three successive years (2013–2015). In order to increase competitiveness of grasses and the yield of the first cut, two N fertilization levels were used: N0 and N50 kg ha<sup>-1</sup>. Two cuts were carried out during the growing season in all three years. The total dry matter yield varied from 9.1 to 12.8 t ha<sup>-1</sup>. The NDF concentration in the DM varied from 495–559 g kg<sup>-1</sup>. Both DM-yield and NDF were dependent on the year, mixture, cutting time and fertilization. Nitrogen fertilization (N50 kg ha<sup>-1</sup>) favoured grass growth and reduced the role of galega in the sward.

**Key words:** Fodder galega, goat's rue, yielding ability, galega-grass mixtures, fertilization.

## Human urine as an efficient fertilizer product in agriculture

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**Abstract.** Flush toilet based water infrastructure, which handles blackwater and greywater together, causes a lot of environmental problems. Among these, the loss of valuable organic material and nutrient content of human excreta (faeces and urine) is not sufficiently emphasized yet. Utilization of human excreta for agricultural purposes is based on the separate collection of greywater and human excreta. As urine contains most of the nutrients of human excreta, researches focus mainly on urine's treatment and utilization for agricultural purposes. We reviewed the data in literature about the nutrient content of human excreta. In this paper we present the content of macro and microelements of human urine to show its potential value as a fertilizer. To confirm the necessity of urine's utilization in agriculture instead of treated it by traditional waste water treatment methods, we have collected and compared the most important advantages and disadvantages of traditional wastewater treatment, separated handling of greywater and excreta as well as human urine's agricultural utilization.

**Key words:** human urine, human excreta, agriculture, wastewater treatment, dry toilets, urine-diversion dry toilets, sustainable development.

## The yield, height and content of protein of field peas (*Pisum sativum* L.) in Estonian agro-climatic conditions

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**Abstract.** *Pisum sativum* L. is important protein crop in the world. The purpose of this investigation was to see whether pea varieties differ in their yield, height and content of protein. Another aim was to select the best varieties suitable for production. Field experiments with different varieties of peas ('Bruno', 'Capella', 'Clara' and 'Vitra') were carried out at the Estonian Crop Research Institute in 2014 and in 2015. Yields (t ha<sup>-1</sup>) in 2014 and 2015 did not differ much, while yield from variety 'Bruno' was very different between years 2014 and 2015 and was much higher in 2015. The most suitable height of field peas is in a range of 60...100 cm, because the plants with such a height are most effectively suppressing weeds. It can be concluded that varieties with suitable height in our investigation were: 'Bruno', 'Capella' and 'Clara'. Variety 'Vitra' was too high, is lodging easily and is therefore hard to harvest. Crude protein content (% in dry matter) was lowest in 'Clara'; all other varieties had a higher content of protein, within much the same range. Based on the results of present investigation it can be concluded that out of those four varieties the most suitable varieties for production are 'Bruno' and 'Capella'. Choice of the right variety for pea cultivation is very important, but depends on the local agro-climatic conditions. As in Baltic – Nordic countries and in north of America the agro-climatic conditions are more or less similar the results are useful for those countries.

**Key words:** height, field pea, protein, variety, yield.

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## System design and the economics of Controlled Traffic Farming in grass silage production

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**Abstract.** The objectives of this work were to: (i) identify the dry matter (DM) yield increase from non-trafficked soil (ii) review the commercially available grass forage equipment that could form the basis of Controlled Traffic Farming (CTF) systems and (iii) determine the economic value of implementing a CTF system for grass production. An extensive literature review was undertaken which indicated a 13% increase in dry matter (DM) yield in the absence of wheel damage. This was in alignment with experimental results reported here comparing grass DM yield between CTF and normal traffic management (N). Commercially available grass forage equipment with widths of 3, 4, 5, 9 and 12 m reduced trafficked areas from 80%–90% for N to 40%–13% for CTF. Reducing the trafficked area from 80% for N traffic to 15%, increased the yield by up to 1.00 t ha<sup>-1</sup> and 1.36 t ha<sup>-1</sup> for 2 and 3 cut systems, respectively. The value of these yield increases varied between €44 ha<sup>-1</sup> and €114 ha<sup>-1</sup> assuming a DM value of €84 t<sup>-1</sup> for grass silage. The cost ha<sup>-1</sup> year<sup>-1</sup> for four low accuracy manually steered systems is less than €21.74 for areas in excess of 100 ha; for four fully integrated high accuracy steering systems the cost is €99.42 for areas in excess of 200 ha, reducing to €13.26 for areas greater than 1500 ha. CTF for a multi-cut grass silage system is cost-effective in increasing yields due to a reduction in the extent of compaction.

**Keywords:** grassland yield, controlled traffic, economic analysis, silage, soil compaction

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## Agricultural use of unmanned aerial vehicles

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**Abstract.** Developments in science and technology make modern life easier and they help us to bring new applications into our lives. In recent years, an innovation that has come into human life is the Unmanned Aerial Vehicle (UAV). When it was used for only military services at the beginning stages, it has been started to be used for commercial or individual purposes in many different areas such as photography, marketing, education, environmental, insurance, tourism, mining, mapping, construction and meteorology depending on technological developments.

In this study, UAVs usage in agriculture will be explained. The main objective in agricultural activities is to increase the farmer's welfare by achieving maximum crop and animal production output per unit area with minimum cost. However, many variations in agricultural production require frequent monitoring and this process causes excessive time and expense by conventional methods.

In particular, by the evolving of UVAs and adopting the fully-controlled imaging systems for these vehicles, UVAs could frequently reveal the current situation of field nowadays. UAVs are using for different purpose such as plant count and data selling, Crop and soil type, growth stage, plant health, plant cover, plant height, canopy cover, leaf area index, soil moisture, water stress and nitrogen deficiencies in agriculture. Thus, helping to minimize the damage because of users can make by quickly making the necessary interventions in time.

**Key words:** UAV, remote sensing, agriculture, image process.

## The effect of different pre-crops on *Rhizoctonia solani* complex in potato

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**Abstract.** *Rhizoctonia* disease in potato is widely distributed in Estonia. Field experiments with cv. 'Red Fantasy' were undertaken with seven pre-crop treatments at the Estonian Research Institute of Agriculture in 2009 and 2010. Monocropped potato, spring barley, spring barley underseeded with red clover, spring wheat, grain pea, spring oil seed rape and oil seed radish were involved in the study as pre-crops. Growing conditions on both years were rather optimal for potato growth but year 2010 was drier at early bulking stage. The effect of different pre-crops on *Rhizoctonia solani* complex was studied (*i.e.* incidence and severity of stem and stolon canker and black scurf) at 15, 30, 45, 60, 90 and 120 days after planting. Results indicated that pathogen-free seed tubers are of primary importance in the disease control and no pre-crop was suppressive to disease if seed tubers had sufficient amount of inoculum. However, to achieve consistent reduction in disease development, inoculum-free seed tubers and crop rotation with non-host crops should be considered.

**Key words:** potato, stem canker, stolon canker, black scurf, chemical control, pre-crops.

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## Influence of manure and activators of organic matter biological transformation on selected soil physical properties of *Modal Luvisol*

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**Abstract.** Agricultural land in the Czech Republic threatened by a combination of water erosion, technogenic compaction and low level of soil carbon. The low levels of carbon in the soil interrelate also with the other threats mentioned. Application of organic matter into soil is one of the ways how to rectify this unfavourable condition. All of its forms can be supplemented by biological transformation's activators. The aim of this paper was to verify the effect of organic fertilizer with a conditioning activator added, i.e. manure from deep-litter housing of dairy cows with PRP Fix added, and the effect of an activator conditioning soil, i.e. PRP Sol, on the change of soil physical properties, i.e soil bulk density, infiltration ability, cone index. In this respect, field trial was established at locality Lázně Bělohrad. Soil infiltration capabilities were measured using a ring infiltrometer with a diameter of 0.15 meters. Cone index was another measured item provided by the registration penetrometer. Bulk densities of each trial variant were evaluated using Kopecky's cylinder. Concerning saturated hydraulic conductivity, all the variants treated with manure demonstrated its increase, namely with soil activators applied as well. Favourable effect on soil bulk density values could have been also observed. The change was often below the level of statistical significance. This could have been caused by a short only time of activator's activity. It can be assumed that the effect is going to be gradual and the verification should be carried out also in following trial years.

**Key words:** activator of organic matter, manure application, soil properties, water infiltration.

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## Nitrogen and carbon release during decomposition of roots and shoots of leguminous green manure crops

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**Abstract.** In Nordic conditions, soils are frozen during winter, affecting the decomposition rates of crop residues. Hence, the decomposition rates of above- and underground biomass and the dynamics of the N and C released into the soil were studied in trials focused on green manure crops. The decomposition of the residue and N release from the residue varied among the five species of legume tested. There was a marked difference in decomposition rates between shoots and roots, which may also be explained by the differences in the chemical composition of the residue. The shoot residue decomposes rapidly and it serves as a source of N for the subsequent crop. The root residue decomposes more slowly and this had a positive effect in a crop rotation in the second year.

**Key words:** C:N ratio, residue decomposition, N and C release, green manure crops, legumes.

**ACKNOWLEDGEMENT.** This research was supported by the Ministry of Agriculture of the Republic of Estonia within the framework of project 'Researching methods of regulating humus status and nutrient balance of soil and phytoproductivity of various green manure crops in conventional and organic farming'.



## **VII PRODUCTION ENGINEERING**

## Wear and stress analysis of chisel

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**Abstract.** The object of research is stress analysis of worn chisel. The interaction between soil particles and chisel leads to change of shape and dimension of a worn chisel or other agriculture tools. The wear rate depends on the velocity of the chisel in the soil, position in the soil and shape of a chisel. These factors change the dimension and shape of chisel during its service life. The modern chisel includes sintered carbides on a tip. Sintered carbides plates are effective protection for wear resistance. But the body of the chisel is not protected and its wear resistance is lower than the tip. The service life of the tip is much higher than the body of the chisel. Stresses of the body of the chisel are stationary during the service life. The aim of this study is determining of optimising process of the strength of steel for chisels.

**Key words:** agriculture tools, FEM, soil, wear.

**ACKNOWLEDGEMENTS.** Supported by 31140/1414/314107 Technological agency of Czech Republic, 'R & D of working tools for agricultural machines'.

## Utilization of the elementary mathematical model for description of mechanical behaviour of composites reinforced by *Ensete Ventricosum* fibres

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**Abstract.** This article is focused on the utilization of elementary mathematical model for description of mechanical behaviour of composites materials reinforced by fibres of *Ensete Ventricosum* under tension loading. Elementary mathematical model was derived for unidirectional fibres oriented in the direction of tension loading and it was experimentally verified. As a matrix it was used a two-component resin Gluepox Rapid and as a reinforcement they were used fibres of *Ensete Ventricosum*. Experimental samples with different volume fibres ratio contained 40, 60, 80, 100, 120 and 140 fibres were tested on tensile equipment MP Test – 5.050. In this study the elementary mathematical model was utilized for description of dependency between modulus of elasticity, rupture stress and volume fibres ratio. From this research follows that data determined from derived elementary mathematical model are significant (on the level of significance 0.05) with experimentally determined data. This derived elementary mathematical model can be used as background for further research related to the modelling of mechanical behaviour of composites reinforced by fibres.

**Key words:** modulus of elasticity, stress at rupture, natural material.

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## Evaluation of quality and efficiency of ventilation equipment by scanning electron microscopy

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**Abstract.** The aim of this research is an evaluation of the quality and function of ventilation equipment in basement rooms. There was analysed the function of ventilation system in relation to the quality of outdoor and indoor environment. The concentration of air dust was measured by exact instrument DustTRAK II Model 8530 aerosol monitor inside and outside the building. Using the special impactors the PM<sub>1</sub>, PM<sub>2.5</sub>, PM<sub>4</sub>, PM<sub>10</sub> size fractions were also measured. Particles separated from the ventilation equipment were examined with SEM (scanning electron microscopy) using a microscope TESCAN MIRA 3 GMX. Obtained results of measurements were evaluated by statistical instruments and concentrations of different size of dust particles were analysed. The size of particles outlet the ventilation equipment was ca. of 55% lower than the size of the particles inlet the ventilation equipment. The difference in tested sizes of the dust particles in the ventilation equipment and outlet the ventilation equipment, i.e. in the place of cleaned air inlet into the basement room, was statistically proved. The diversity of impurities caught by the ventilation equipment and impurities moving in the air in the tested room is obvious from the results of SEM analysis.

**Key words:** dust, fraction, scanning electron microscopy, ventilation.

## Determining the specific heat capacity and thermal conductivity for adjusting boundary conditions of FEM model

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**Abstract:** One of modern way of the heat treatment process of agricultural tools such as chisels or tines is FEM modelling. FEM models needs the accurate boundary conditions for successful solution. Specific heat capacity and thermal conductivity are important parameters for the design of the physical properties of heat treatment. These parameters are used for the formation of the temperature field during the cooling process at the heat treatment. More accurate parameters allow you to better estimate the final microstructure in the entire cross-section of the material. Specific heat capacity and thermal conductivity are known from material sheets, but they are stated as constant values. This is the reason why this work is focused on the determination of specific heat capacity and thermal conductivity of steel during the quenching. For the experiment in this work was chosen material 25CrMo4. The values of specific heat capacity and thermal conductivity were determined by comparing the experimentally measured cooling curves and cooling curves generated by the mathematical model. The dependences of specific heat capacity and thermal conductivity were compared in temperature, so that the relationships of cooling curves were statistically significant under alfa level 0.05.

**Key words:** specific heat capacity, thermal conductivity, FEM model, quenching.

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## Influence of chemical cleaning of adhesive bonded surface on working environment and adhesive bond quality

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**Abstract.** Undesirable chemical substances are released into the environment at single manufacturing operations, namely at a chemical treatment /cleaning of an adhesive bonded surface. The chemical treatment /cleaning of namely metal adhesive bonded surface before an application of the adhesive represents a significant factor having an influence on a resultant adhesive bond strength, i.e. adhesive and cohesive strength.

Producers do not provide information about releasing harmful substances into the atmosphere, i.e. mass values of a flow of polluting substances used at the chemical cleaning of the adhesive bonded surface. These cleaning agents were experimentally investigated.

The aim was to evaluate an adhesive bond quality depending on the chemical treatment of the adhesive bonded surface and the intensity of the chemical agent release into the atmosphere. The adhesive bond quality was evaluated by means of mechanical tests and SEM analysis.

The increase of the adhesive bond strength does not conclusively occur when using the chemical treatment of the adhesive bonded surface compared to the adhesive bonds with only mechanical treatment of the adhesive bonded surface, except for the chemical cleaning in the acetone bath. This treatment proved always in a positive way.

**Key words:** adhesive bond, chemical treatment, chemicals contamination, evaporation.

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## Investigation of coaxial laser cladding process parameters influence onto single pass clad geometry of tool steel

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**Abstract.** This paper is devoted to the investigation of the influence of technological parameters on the single pass clad geometry and quality as well as elemental composition in the clad after coaxial laser cladding (CLC). The objects of the investigation are components of expensive machines and tools for presswork needed to be repaired, i.e. refurbished for the future application with the goal of effective using of material resources in production. Nowadays such repair of worn tools is an actual task due to tendency for thrifty management of resources at affordable cost. Experimental work was carried out using CLC system, which consists of industrial robot and a ytterbium fiber laser with a core diameter of 100  $\mu\text{m}$ , integrated to the coaxial powder supplying cladding head. During research separate cladding tracks of metal powder AISI M2 (particle size 53–150  $\mu\text{m}$ ) were deposited on the top surface of steel plates, which were grinded before treatment. This work's highlighted parameters for variation were laser scanning speed and laser beam focus plane distance. The clad geometry was examined on cross-sections with SEM. Elemental composition was determined by the X-ray spectroscopy analysis. Gladding beads with good surface quality were achieved. Cross-sectional observation presented that clads has a good fusion with the base material without exfoliation. Keyhole shape of molten substrate area was achieved, which leads to increase of the dilution value. The future research is needed to achieve stable quality of cladding, which is extremely necessary for industry.

**Key words:** coaxial laser cladding, tool steel, clad geometry, keyhole in penetration.

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## Band structures for binding and holding of objects made from recycled metallic materials

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**Abstract.** The aim of the present research is the investigation of the possibility and effectiveness of using the band structures made from recycled metallic materials for binding and holding of objects (in particular, tubular objects as pipelines or shells). The using of band elements and structures as such is a perspective way to increase the safety and bearing capacity of the pipelines and vessels. Nowadays during repair works the outer surfaces of the mentioned objects are braided by the steel tapes, i.e. the objects are strengthened by the binding. The mentioned steel bands are specially produced for binding purpose. From the other hand after stamping of small-size details (like the elements of supply chains for different apparatus) the metallic waste in the shape of perforated metallic tapes are received and needs to be reused in compliance with the good practice in effective resource using and recycling. The band structures for binding and holding of tubular objects, produced from the perforated metallic tape by the longitudinal profiling, multilayer and spiral winding are presented. It is proposed to apply in industry the composite band structures made from perforated metallic materials and epoxy matrix for binding and holding of tubular objects as pipelines or shells, which allows simplifying and speeding up the repair works especially in the cases of the local damages.

**Key words:** perforated metallic waste, pipe repair bandages, environment.

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## Mathematical model describing the drying curves of false banana's fibre (*Ensete ventricosum*)

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**Abstract.** Drying processes play an important role in the preservation of agricultural products. They are defined as a process of moisture removal due to simultaneous heat and mass transfer. This study was focused on the analysis of drying curves of fibres of false banana (*Ensete ventricosum*). The fibres of *Ensete ventricosum*, originally from Ethiopian region Hawasa, were used in this experiment. Moisture content of freshly harvested fibres  $M_c = 78.4 \pm 1.4$  % (w.b.) were determined. The fibres were dried at different air temperatures  $T_d = 40, 60, 80$  and  $100 \pm 1$  °C. To determine the drying curves the drying moisture balance (Radwag, MA 50.R, Poland) was used. Measured data were analysed by computer software Mathcad 14. Experimental drying curves at different temperatures and drying rate were determined. Basic mathematical model describing the loss of mass by drying of the *Ensete* fibres was represented. The model coefficients were statistically significant suggesting that the determined model could be used as a background for further research focused on *Ensete* fibre application.

**Key words:** drying kinetics, moisture content, drying rate.

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## Mechanical properties of resin reinforced with glass beads

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**Abstract.** The research was focused on the evaluation of a loading speed and a size of the particle filler in a form of glass beads B159 and B112 on resultant behaviour of a composite material and during its application in a structural adhesive bond. A fall of the tensile strength of the composite material of ca. 60% is obvious from the experiment results when adding both fillers (B159 as well as B112). This composite material showed in the positive way as the adhesive at the adhesive bonds. The experiment results proved the positive influence of adding the particle filler of the spherical shape – glass beads B159 (the fraction size  $85.23 \pm 31.23 \mu\text{m}$ ) on the adhesive bond strength. The adhesive bond strength was increased up of 14% at the filler glass beads B159. However, adding the filler into the resin proved that this filler eliminated the influence of various loading speeds. Adding the filler into the resin changed a fracture surface. An analysis of a scanning electron microscopy (SEM) proved a good wettability of the filler, the resin and the adhesive bonded material (a structural carbon steel S235J0). A crack propagation was concentrated around the filler B112 ( $151.59 \pm 53.04 \mu\text{m}$ ), namely at higher value of the loading speed, i.e.  $10 \text{ mm min}^{-1}$ . The crack propagation is a consequence of this. Higher particles show in a negative way namely at an initiation of the fracture surface.

**Key words:** Loading speed, particle filler, SEM, strength.

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## Measurement of weld joint parameters and their mathematical modelling

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**Abstract.** The article deals with verifying of weld quality of weld joints created by laser beam welding technology, primarily in agricultural components such as reel screws. We presents both metallographic check of the weld structure using electron microscopy, RTG-microanalysis and micro hardness measurement as well as used mathematical models of the welding process and respective weld joints geometry.

First the laser beam welding technology and concerned agricultural components are introduced. Further we specify individual steel types as well as laser types and we define specific welding parameters used in our measurements. We selected several samples of weld joints, which are further examined them in detail using optical microscopy, micro hardness measurements and RTG microanalysis. We further determined the weld shape, measured dimensions of individual weld joints as well as we checked the weld joints structure.

We further introduced a mathematical model based on the program ANSYS. The model can simulate temperatures, speed field and tensions within the weld joint, basing on known thermal conductivity of the base material and specified welding conditions. Using the model, we can predict the shape of the weld and the temperatures within the material. Finally, individual welding parameters and obtained weld joint samples are briefly discussed and the applicability of the model is evaluated.

**Key words:** steel, mathematical modelling, screw, laser welding, metallographic check.

## Mechanical qualities of adhesive bonds reinforced with biological fabric treated by plasma

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**Abstract.** The paper deals with the utilization of a biological reinforcement in the area of an adhesive layer at structural adhesive bonds. A significant disadvantage of adhesive bonds is uneven layer of an adhesive, which can be eliminated by various technological procedures. One possibility is to use a reinforcing even layer. The primary aim of this paper was to experimentally investigate an influence of the surface plasma treatment of natural fabrics (flax, cotton) at different intervals of plasma affecting (0 to 90 seconds and power 350 W) on mechanical properties of the adhesive bond. There were positive results from reinforcing the adhesive bond by a layer of linen and cotton. Strength characteristics of reinforced adhesive bond were increased compared to non-reinforced adhesive bonds. When the linen was used, the strength was increased by 43.2% and when the cotton then 15.5% strength increase could be seen. When modifying the surface by plasma, next adhesive bond's strength increase was seen. Using the linen there was approx. 47% strength increase, using the cotton the strength increase was approx. 38% compared to non-reinforced adhesive bonds (without reinforcing phase). It is obvious from the results that plasma modifying showed better results when the cotton was used as the reinforcing material. SEM analysis proved that adhesion was improved with plasma surface modification of biological fibres. In other words the distance between the warp and the resin was significantly decreased for 87.1% when using the cotton and by 46.5% when the linen was used.

**Key words:** Cotton, flax, plasma treatment, SEM.

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## Contactless measurement and evaluation machined surface roughness using laser profilometry

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**Abstract.** This article provides a detailed description of the system for automated control of surface roughness parameters and selected characteristics by laser profilometry. It detailed describes the software, hardware and other parts of the device for measuring the surface roughness of the components. Further it describes the behavior of these individual parts functioning as a whole, and ways to measure samples using the means of contactless measurement of object profile along the defined profile cross-sectiona by the technology of optical profilometry. The article also describes the innovative solution to the measurement of problem types of surfaces such as polished surfaces, where it is partly prevented the use of specific or non-traditional methods of polished surface modification. For measurement and evaluation of measurement data, it was found that the device for measuring the roughness, basically intended for the operation of the Department of the production process, meets our specifications in the field of software and hardware and is ready for further use.

**Key words:** contactless, measurement, evaluation, surface, roughness, profilometry.

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## Influence of sisal fibres on tribological properties of epoxy composite systems

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**Abstract.** Composite are materials, which synergically combine properties of the matrix and fillers. An interaction of polymers – resins – with biological kind of fillers can optimize their mechanical properties in the same way as synthetic fillers. Biological fillers have many advantages, which include low price and satisfying mechanical properties. Significant disadvantages are different properties of fibers – for example, fibre diameter and strength – which are caused by the biological essence of this material. The design of new composite materials based on natural renewable resources is essential for an environment and is also attractive from an economic point of view. This paper describes the hardness and resistance to abrasive wear of epoxy resins filled with unordered short sisal fibers (3, 6 and 9 mm). Scanning electron microscopy was used to assess the fibers and interaction between fibers and epoxy resin.

**Key words:** Abrasive wear, Agave Sisalana, electron microscopy.

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# **VIII RENEWABLE ENERGY & POWER ENGINEERING**

## Impact of differences in combustion conditions of rape straw on the amount of flue gases and fly ash properties

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**Abstract.** The rising trend of biomass energy usage as a renewable energy source raises issues with combustion waste products, mostly bottom ash and its potential for further use. Rape straw was selected as a fuel sample for experiments because of the fact, that this crop figures among the 10 most important crops in the world and its straw is frequently used as a source of renewable energy. The rape straw was processed in pelletizing line LSP 1800 of the company ATEA PRAHA Ltd. into pellets with diameter of 8 mm and length 15 to 30 mm. Composition of bottom ash arising during the energy utilization of biomass is primarily dependent on the composition of input raw material and next on the combustion technology. Therefore, the aim of this article is to clarify the influence of excess air amount on the composition of end products in combustion of rape straw pellets in three combustion modes (low, optimal and high excess air).

The last part of study were combustion tests and measurements on a laboratory hot-air stove – KNP from the company KOVO NOVAK. Excess air coefficient values ranged between 3.31 and 6.77. The average net calorific value of the original rape straw sample was about 15.95 MJ kg<sup>-1</sup>. Input raw material may not have always been completely combusted in the device, and therefore the ash could contain elevated amounts of hazardous elements. These substances are a limiting factor for application of the ash into soil. Overall, ash from biomass not only offers a wide range of potential applications thanks to its physical and chemical properties, but also returns some of the nutrients back to the soil closing the nutrient cycle and reducing the landfill of such material. And last but not least it enables cost reduction in agricultural production spent on mineral fertilizers.

**Key words:** rape straw, combustion conditions, ash properties, emission concentrations, flue gas temperature.

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## Performance analysis of biodegradable municipal solid waste collection in the Czech Republic

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**Abstract.** The article deals with the issues of biodegradable municipal solid waste management system, focusing on its separate collection. The two basic locations are compared – rural area and urban area. The emphasis is put on evaluation of individual biodegradable municipal solid waste collections development from 2012 to 2015. Individual technological performances of collection are also observed and evaluated (e.g. biodegradable municipal solid waste production, development of container quantity and collection frequency). The observed data also verify the efficiency of biodegradable municipal solid waste management compared to relative representation of this waste in rest municipal solid waste, which is produced in both locations. Also referential locations without separate biodegradable municipal solid waste collection are observed for evaluation. There are one locality of an urban area and one rural area too. The decrease of biodegradable municipal solid waste in rest of municipal solid waste at the basic rural researched area indicates that the directive on landfills could be followed with well-chosen technological parameters of separate biodegradable municipal solid waste collection at a given site. A statistically significant impact of separate biodegradable municipal solid waste production on relative amount of the biodegradable part in rest municipal solid waste has been demonstrated at the side of this basic rural area.

**Key words:** municipal solid waste, rest municipal solid waste, biodegradable municipal solid waste, biodegradable municipal solid waste collection, material analysis.

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## Comparison of reliability of false rejection rate by monocriterial and multi-criteria of biometric identification systems

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**Abstract.** Biometric user identification is a highly topical theme these days. The most widespread areas are identification of a person on the basis of fingerprints and identification on the basis of facial features. Testing was performed on the 4 biometric systems. Systems using fingerprint were LA 2000M and iEvo ULTIMATE, and systems disposing even the scan faces were D-Station, iFace 800. Measurements showed that the higher reliability have biometric identification systems which identify the person on the basis of one parameter. From the results it is also seen that sabotage of biometric identification devices that identifies on the the basis of two or more parameters is much simpler than those that identify only using fingerprint or scan of face.

**Key words:** fingerprint, false rejection rates, false acceptance rates, identification.

**ACKNOWLEDGEMENTS.** It is a project supported by the CULS IGA TF 2016 'The University Internal Grant Agency' (2016:31150/1312/3110).

## Dry sorption stabilization of flue gases in biological waste incinerating facility with heating power under 5 MW

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**Abstract.** Biological and medical waste is always classified as hazardous material such as it must be treated according to its hazardous characteristics. One of the best methods for disposal seems to be a thermal degradation. This research examines the effect of finely crushed sorbent  $\text{Ca}(\text{OH})_2$  and  $\text{NaHCO}_3$  to eliminate these hazardous substances in a small incinerating facility with heating power under 5 MW. The experiment took place in an existing incinerating plant with capacity  $250 \text{ kg h}^{-1}$ . Sorbents were injected into a flue gas flow at two different places. It was observed that the temperature of flue gas and the residence time significantly influence the sorbent refining effect that is caused by quantity of collision in flue gas stream. Sorbents were dosed into a system with a theoretical consumption excess to serve sufficient refining effect. At dosing rate of  $7 \text{ kg h}^{-1}$   $\text{Ca}(\text{OH})_2$  the concentration of  $\text{SO}_2$  decreased by 34.5% and HCl by 59.0% referring to the initial concentration. At dosing rate of  $5 \text{ kg h}^{-1}$   $\text{NaHCO}_3$  the concentration of  $\text{SO}_2$  decreased by 32% and HCl by 44.8% referring to an initial concentration. Tested sorbents react with acidic compounds with different efficiency and preferably react with different acid compounds.

**Key words:** hospital waste, Calcium hydroxide, Sodium bicarbonate, HCl,  $\text{SO}_2$ .

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## Development and testing of apparatus for wooden chips voids measurement

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**Abstract.** The interparticle porosity of wooden chips (commonly called voids) is a very important factor which significantly affects properties of wooden chips, i.e. bulk density, combustion speed or dielectric properties. Dielectric properties can be used for the measurement of its moisture content and it is the moisture content which is one of the most important factors that affect wooden chips calorific value. This paper is focusing on the development of measuring apparatus for wooden chips voids measurement. The principle of measuring apparatus is based on a gas displacement method. Measuring apparatus is composed from two chambers; both with the same volume. One from chambers is comparative one and second is experimental one. The pressure operating range was from 1,000 to 1,500 Pa. Results showed nontrivial behaviour of wooden material with the change of moisture content which was probably caused by different structures of tested materials.

**Key words:** wooden chips, porosity, gas displacement method.

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## Multilayer material for electromagnetic field shielding and EMI pollution prevention

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**Abstract.** A significant growth of scientific activities related to electromagnetic fields interaction with equipment and living organisms have turned into an up-to-date research trend in recent decades. Power transmission lines, electric devices, and portable electronics have become a source of electromagnetic pollution. Therefore, a question of electromagnetic shielding is a substantial criterion for workplace safety. Current paper suggests a possible solution based on loose materials and rubber compounds for essential protection of people and equipment against electromagnetic influence.

**Key words:** crumb rubber, iron powder, electromagnetic shielding, perforated steel, multilayer structures.

**ACKNOWLEDGEMENTS.** Support for this work was provided by the Riga Technical University through the Scientific Research Project Competition for Young Researchers No. ZP-2016/37.

## A dynamic model of electric resistor's warming and its verification by micro-thermocouples

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**Abstract.** The object of research is a resistor, a real electronic component, loaded by constant or impulse power. As a first approximation, resistor follows 1st order dynamic system, i.e. heating of the hottest spot on its surface is exponential to the power increase. The validity of this model is confirmed by measurements in a constant power loading regime. In an impulse power loading, it is only valid when the pulse duration approaches time constant of the resistor. The aim of this article is to show more credible model warming of the resistor, which is valid even for the case of pulse duration (ms) much shorter than the time constant of the resistor. The model can reveal an overload which does not lead to destruction of the resistor. Dynamic model of the resistor is based on its construction. Typically, an insulating ceramic rod is coated with a resistive layer connected with outlet wires on both sides, all being coated with insulating lacquer layer. The resistive layer is a source of heat flow. Formulation of the model comes from general power balance in a form of three differential equations and it is solved using Scilab. The input variable is the impulse power and the outputs are temperature changes in the ceramic rod, the resistive layer and the lacquer layer, compared to the ambient temperature. The simulation allows to determine solutions for various parameters including very short power pulses, which are confirmed experimentally.

**Key words:** load factor, model, resistor, thermocouple, warming.

## The dependence of CO<sub>x</sub> and NO<sub>x</sub> emission concentrations on the excess air coefficient during combustion of selected agricultural briquetted by-products

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**Abstract.** The issue of CO, CO<sub>2</sub> and NO<sub>x</sub> emissions is very extensive and important. The aim of the paper is the experimental determination of the CO, CO<sub>2</sub> and NO<sub>x</sub> emission dependencies on the amount of excess air. Materials used for the experiments were several types of briquetted biomass. Crops used were Czech knotweed (*Reynoutria × bohemica*), Rumex hybrid OK 2 (*Rumex patientia × Rumex tianschanicus*), meadow hay and timothy grass (*Phleum pratense*). For all samples proximate and elemental analyses were performed (semiautomatic calorimeter LECO AC-600 elemental analyser CHN628 + S and analyser LECO TGA-701) and stoichiometric calculations of combustion were made. Combustion device used in combustion tests was a hot air stove with a grate fireplace and with manual fuel supply. The combustion process was monitored by analyser Madur GA-60. Parameters monitored during the combustion tests were primarily the flue gas temperature and the emission levels of carbon monoxide, carbon dioxide and nitrogen oxides.

Analyses and calculations of plant biomass samples indicate their good properties for energy use. The gross calorific value was as high as 19.55 MJ.kg<sup>-1</sup> in the sample of Rumex OK 2. Limiting factor is the high quantity of ash in plant material. The briquettes from timothy grass achieved 5.77% wt. ash in the dry matter. The excess combustion air had positive influence during combustion test. On the other hand, this caused heat loss by departing flue gases, wherein the flue gas temperature reached high values. The excess air coefficient also significantly affected the emission levels of carbon dioxide and monoxide and nitrogen oxides in the flue gases. Results were statistically analysed and complemented by regression equations, which in practice can be used to optimize the combustion process in boilers with manual fuel supply.

**Key words:** plant biomass, combustion device, calorific value, combustion gases, heat loss.

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## Seabed sediment – a natural seasonal heat storage feasibility study

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**Abstract.** The new discovery among renewable energy resources, seabed sediment, has been utilised as a heat source for 42 houses in Vaasa since 2008. Sediment heat is annually loaded by the Sun. In this study the amount of annually charged energy is estimated. The difference of sediment temperatures between the coldest and the warmest month during the year is a key value in the approximation of the loaded energy. Sediment temperatures are measured once per month via optical cable by distributed temperature sensing (DTS) method. The monitoring period is three years, 2014–2016. The estimation of incoming energy (575 MWh) versus known exploited energy (560 MWh) is reasonable. Despite of the extraction this seasonal heat storage in the seabed of the Baltic Sea seems to reload well annually.

**Key words:** renewable energy, sediment heat, distributed temperature sensing, heat storage.

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## The use of unsteady method for determination of thermal conductivity of porous construction materials in real conditions

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**Abstract.** The possibility to determine the thermal conductivity of construction materials outside the laboratory conditions is useful for professional practice mainly for control and inspection activities on real existing buildings. The requirement to determine the thermal conductivity can be useful above all for different thermal insulation materials but for other materials as well, even for compact soils or rocks. This paper describes methods and instrument which can be used for these measurements, as well as the results of measurement of porous building materials. Measurements presented in this paper were carried out by the needle and surface sensor. Four different materials were selected for verification of technical parameters of Isomet 2104. Besides the thermal conductivity there were determined also thermal diffusivity and volume-specific heat capacity of materials. The carried out measurements confirmed the applicability of this device for practical measurements of thermal conductivity in real conditions. For porous materials, there were determined significant differences between the data presented by the manufacturer or in the literature and measured values, in some cases. Differences between the measured values of thermal diffusivity and volume-specific heat capacity of porous materials were always statistically significant. Authors tested different materials including thermal insulation based on agricultural products.

**Key words:** dynamic method, measurement, sensor, thermal properties.

## Optimization of the balancer for $\text{LiFePO}_4$ battery charging

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**Abstract.** Balancers of various constructions are currently used for the operation control of the batteries connected in series. Unidirectional balancers ensure proper charging of all battery cells in a way that the first loaded cells should not be overcharged. Active balancers distribute the power, supplied to already-charged cells, to other cells; the power is further consumed by the passive balancers. Bidirectional balancers enable distributing the power between the cells during the discharge process, as well. This process thus protects the fastest discharging cells against the deep discharge. Passive balancers are most often used in batteries charged by the currents up to 20 A. If there are not big differences between individual cells in the battery, passive balancers reduce the efficiency of the charging process by only a few percent. They are the cheapest and most reliable. Optimally adjusted balancers with very low internal resistance deteriorate the efficiency only by about 1%. Commercially available balancers, working on the principle of a switch, periodically connecting the load resistor to the cell, deteriorate the efficiency to a greater extent, by about 5%. Optimized balancers, whose construction is described in the paper, work on a principle of a linear feedback controller. They can work with a maximum charging current up to 20 A, they have very low dynamic resistance of about 1 m $\Omega$ , and are absolutely stable. Their properties are further compared both with previously used circuits and commercial circuits.

**Key words:** balancer,  $\text{LiFePO}_4$  accumulator, isolated solar power system.

**ACKNOWLEDGEMENTS.** Thanks for cooperation belong to Laboratory of Photovoltaic Systems Diagnostics, Faculty of Electrical Engineering, Czech Technical University in Prague and Department of Electrical Engineering and Automation, Faculty of Engineering, Czech University of Life Sciences in Prague.

## Endurance LiFePO<sub>4</sub> battery testing

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**Abstract.** A lithium-iron-phosphate (LiFePO<sub>4</sub>) battery is nowadays considered one of the best types of batteries. Manufacturers and mostly suppliers indicate that LiFePO<sub>4</sub> batteries have much longer lifespan than other batteries, and thus convincing their customers of lower operating costs than at other types of batteries, although their purchase price is several times higher. In connection with the problem of replace Pb batteries in the backup sources of security systems with LiFePO<sub>4</sub> batteries, there has been necessary to determine the real parameters of available cells under conditions in which they operate. The paper describes the battery tests, in which their real parameters, comparable with the parameters indicated by the suppliers, are tested. The tests lie in automatic long-term cyclical charging and discharging of the multi-cell battery. Operating parameters are continuously monitored, recorded and evaluated by the computer. Individual cells are equipped with balancers and protection circuits that prevent from exceeding the maximum voltage during charging, as well as the voltage drop below a minimum level during discharging. The results of long-term tests on LiFePO<sub>4</sub> WB-LYP40AHA Winston Battery are presented. The first test was conducted with 100% depth of discharge (DOD). New cells, after the first charge and discharge, showed the capacity about 115% of the rated capacity, the capacity drop c. 0.015 to 0.02% per cycle and the capacity drop to 80% after 950 cycles, which represents a lifetime of about 5% less than state the manufacturers.

A second test was conducted with 50% depth of discharge. Here, again after the first charge and discharge, new cells exhibited the same capacity as in the first case, i.e. c. 113% of the rated capacity. After 1,000 cycles, the cell capacity decreased to 107% of the rated capacity, which corresponds to the expected lifetime of 5,000 cycles.

**Key words:** LiFePO<sub>4</sub> battery, lifespan, capacity drop, depth of discharge.

**ACKNOWLEDGEMENTS.** Thanks for cooperation belong to Laboratory of Photovoltaic Systems Diagnostics, Faculty of Electrical Engineering, Czech Technical University in Prague and Department of Electrical Engineering and Automation, Faculty of Engineering, Czech University of Life Sciences in Prague.

## Indirect measurement of the battery capacity of smart devices

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**Abstract.** A crucial part of portable electronic devices (smartphones, smart watches, Tablet PCs, GPS devices, etc.) are the batteries. The dominant trend in the design of these devices is such that the users are not supposed to replace the batteries, i.e. the device's battery is meant to last for the entire lifetime of the device. This makes it important to know the capacity of the battery in order to estimate the expected life of the portable device. As there is no access to the terminals of these batteries, it is not possible to use traditional direct methods to evaluate the capacity of the battery and an indirect method needs to be used. The aim of the given research is to propose different indirect methods of battery capacity measurement and assess their accuracy.

**Key words:** smart device, battery life, capacity, indirect measurement.

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## Experimental evaluation of hydraulic design modifications of radial centrifugal pumps

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**Abstract.** In the field of small hydropower, pump units in turbine mode (PAT) are frequently used as alternative to conventional turbines. In order to maximize their operation efficiency, it is possible to optimize the performances of these engines through various simple innovative modifications which relate mainly to the geometry of the flow parts. This paper deals with the results of several successful modifications verified on one such engine. While various simple modifications led to the increase of overall efficiency and power output by few percentages, power output increased by nearly 30% with the innovated runner blades geometry. The modifications also had positive effects on the pump's operation, with significant increases in flow rate, head and total efficiency.

**Key words:** pump as turbine (PAT), efficiency, innovation, turbine mode, pump mode.

## Contribution of pumped hydro energy storage for more RES utilization on autonomous power systems

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**Abstract.** This paper addresses the performance issues of autonomous power systems under high renewable energy sources (RES) penetration. Renewable energy sources could be the main option for isolated power generation at remote locations in case that energy storage introduced. At the moment, pumped hydro storage (PHS) units and batteries storage systems (BSS) represent the most mature technologies for large scale energy storage. The basic criteria for this kind of energy storage unit installations include, (a) the existence of an autonomous power system with local power stations, (b) the high electricity production cost, (c) the potential of renewable energy sources (mainly wind and solar), and (d) the non-flat terrain morphology (for PHS). Greek islands represent ideal cases for large scale energy storage installations, as they fulfil all the above criteria. This paper shows the effect of the installation of a planned PHS unit in Crete island. The calculations are based on real data provided by the Cretan power system operator, whereas the results show the effect of energy storage units operation on the energy mix, as well as the economic viability of the project, which is combined with significant environmental benefits.

**Key words:** Isolated power systems, energy storage, pump hydro systems, renewable energy sources.

## **IX VEHICLES & FUELS**

## Effects of change in the weight of electric vehicles on their performance characteristics

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**Abstract.** One of the parameters of electric vehicles that can affect their dynamic and range characteristics is their weight. Converting a vehicle with an internal combustion engine into an electric one, it is possible to vary its batteries and their placement. It is also possible to choose batteries of various capacities for serial electric vehicles, for example, Tesla Model S. Not only the costs of electric vehicles but also such performance characteristics as dynamics and travel range per charge depend on the number of batteries and the total weight of the electric vehicles. The research developed and approbated an algorithm for calculating comparative parameters for electric automobiles. The algorithm was approbated on 30 electric automobiles of various makes. Energy consumption per km distance travelled shows the exploitation cost of an electric automobile. According to this indicator, the most economical electric automobiles were as follows: Renault Twizy ( $67.8 \text{ Wh km}^{-1}$ ), Tazzari Zero ( $87.9 \text{ Wh km}^{-1}$ ) un Renault Zoe ZE22 ( $93.6 \text{ Wh km}^{-1}$ ).

**Key words:** batteries, range, batteries capacity, energy consumption, weight coefficient, gross weight.



## Diesel fuel filtration improvement at low ambient temperatures

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**Abstract.** Modern diesel engines are equipped with precise fuel injection systems. For functioning of such system not only good quality clean diesel fuel is necessary, but also a sufficient amount of fuel to ensure the high-pressure pump efficient operation also at low ambient temperatures. Therefore, it is necessary to provide the necessary pressure also at the fuel system's low pressure part. In order to comply with this condition it is not enough with correct pump functioning, the fuel filter permeability is very important. Therefore, a study was conducted on the diesel fuel filter permeability at low ambient temperatures, and solutions to improve the filtration were found. Three types of fuel were used in investigation: 1<sup>st</sup> arctic class fossil diesel, biodiesel B100 and pure rapeseed oil. In order to improve fuel filtration process the two and three parallel filter circuits were implemented in the fuel system. The results show that the benefits of using multiple filters depend on the used fuel. The greatest benefit was observed for rapeseed oil fuel using three parallel filters. The usage of pure rapeseed oil is possible even at -16 °C. The biodiesel flowability at -24 °C increased 1.3 times.

## Effect of commercial diesel fuel and hydrotreated vegetable oil blend on automobile performance

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**Abstract.** The new fuel 'Pro Diesel' that contains hydrotreated vegetable oil (HVO) was recently introduced in Baltic market. It raised some interest on performance of the new fuel among fleet and individual consumers. The authors evaluated and compared performance of modern M1 class automobile, using regular fossil diesel fuel and Pro Diesel fuel.

Torque, power and fuel consumption of the vehicle have been evaluated on chassis dynamometer, in steady state and driving cycle mode.

Depending on test conditions, engine power and torque was increased up to 2%, and fuel consumption reduced up to 3.9%, when diesel fuel/ HVO blend was used.

**Key words:** Pro Diesel fuel, HVO, NexBTL, compression ignition engine, fuel consumption, power, torque.

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## Experimental analysis of hydrotreated vegetable oil (HVO) and commercial diesel fuel blend characteristics using modified CFR engine

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**Abstract.** Performance parameters of different commercial diesel fuels is a subject of interest for fuel consumers. Fuel retailer Neste recently introduced a new brand of WWFC 5th grade diesel fuel in Baltic market, consisting of diesel fuel and hydrotreated vegetable oil (HVO) blend. Fuel samples have been recently tested on chassis dynamometer, measuring wheel power and torque and in road conditions, measuring fuel consumption. Evaluation of fuel consumption and performance parameters in road or laboratory conditions may yield uncertain results due to complexity of modern automobile engine management and emission reduction systems. To better evaluate the combustion, fuel samples have been tested in modified CFR engine at various intake air pressure, temperature and compression ratio settings. Engine indicated performance parameters and combustion phasing of regular diesel fuel and diesel fuel-HVO blend are presented. Comparing to regular diesel fuel, fuel blend with HVO showed reduced apparent heat release rate (AHRR) during premixed combustion phase at low inlet air temperature and low compression ratio conditions, comparing to regular diesel fuel. Premixed combustion phase AHRR of diesel-HVO blend increased above AHRR of regular diesel fuel at higher inlet air temperature and higher compression ratio conditions. Diffusion controlled combustion phase AHRR of diesel-HVO blend increased above AHRR of regular diesel fuel at higher inlet air temperature, higher compression ratio conditions and supercharged air supply.

**Key words:** Compression ignition, internal combustion, autoignition, heat release, ignition delay, IMEP, paraffinic fuel, NextBTL, biofuel, renewable fuel.

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## Experimental analysis of combustion process in SI Engine using ethanol and ethanol-gasoline blend

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**Abstract.** Effect of fuel composition and ignition timing on combustion parameters of spark ignition (SI) port fuel injection (PFI) engine had been studied experimentally. The engine was fuelled with an ethanol and ethanol-gasoline blend E85. The engine was operated at steady speed at 1500 min<sup>-1</sup> and four load points have been used. Minimal ignition timing advance for maximal brake torque (MBT) at stoichiometric air/ fuel ratio for the tested fuels were found. The fuels were tested at their respective MBT timing and gasoline MBT timing. MBT timing was retarded by 8–11% for ethanol and 5–10% for E85 fuel, comparing to gasoline MBT timing. Indicated mean effective pressure (IMEP) was not affected by ignition timing in tested conditions. Maximal cylinder pressure was increased and flame development phase was extended, when gasoline MBT was used with fuels with high ethanol content at tested conditions.

**Key words:** Spark ignition, MBT, E85, bio fuel, renewable fuel, heat release, burn duration, combustion, IMEP.

## Comparison of PM production in gasoline and diesel engine exhaust gases

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**Abstract.** The article is focused on different kind of combustion engines and their particulate matter production. The first part of experiments dealt with particulate matter production under defined driving cycle and operating regimes. The second part of experiments was carried out to measure the maximal PM production under engine's full load regime. The experimental vehicle engines were manufactured by Skoda Auto a.s., equipped with modern fuel injection systems. Two representatives of diesel engines were chosen: the engine EURO-4 1.4 TDI with PD (Unit injector) injection system and the EURO-6 1.6 TDI with common rail injection system and DPF. As two representatives of gasoline EURO-4 engines were chosen: 1.2 MPI with non-direct fuel injection system and 2.0 FSI with direct stratified fuel injection system. The analysis of the particulate matters was carried out on a TSI Engine Exhaust Particle Sizer 3090 that is able to classify particles from 5.6 nm to 560 nm. In the case of diesel engines the results proved expectable decrease in PM production due to usage of diesel particulate filter (DPF). The older engine without DPF produced more than hundred times higher PM production under all operating regimes of driving cycle. The result of gasoline engines confirmed increased PM production of direct injection systems especially under higher engine load. FSI engine in driving cycle reached up twenty times higher PM production than MPI engine.

**Key words:** particulate matter, MPI, FSI, DPF, PFI, common rail, carburettor, size distribution, driving cycle.

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## Comparison of exhaust emissions and fuel consumption of small combustion engine of portable generator operated on petrol and biobutanol

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**Abstract.** The paper is focused on the comparison of exhaust emissions and fuel consumption of small internal combustion engines operated on petrol and biobutanol. In case of this research, small engines are represented by combustion engine of portable power generator with nominal power of 4.8 kW equipped with carburettor for fuel mixture preparation. Exhaust emissions and fuel consumption were measured while gradual loading of the combustion engine. BrainBee emission analyser, Bruker FTIR spectrometer and EEPS particle analyser was used for the measurement. The mass fuel consumption was monitored using laboratory scale Vibra. The initial hypothesis expected that exhaust emissions and fuel consumption will be higher in case of use of nonstandard fuels. From the viewpoint of particles count can be stated, that their productions are at very low level for both kinds of used fuels. Production of carbon monoxide and hydrocarbons is higher than in case of usual automobile engine due to simple engine control system and absence of additional emission control device (catalytic converter). The fuel consumption increased while using n-butanol as a result of its lower calorific value.

**Key words:** biobutanol, petrol, emission, fuel consumption.

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## Selection and evaluation of degradation intensity indicators of gas combustion engine oil

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**Abstract.** The paper is focused on the analysis of data obtained during the operation of gas combustion engines running on biogas. The observed engines were running continuously in cogeneration units of biogas plants. The long-term operational monitoring of engines operating on biogas was carried out using tribotechnical diagnostics methods focused on oil properties. Each of individual indicators was determined in obtained time series. As critical indicators oils were identified oxidation, sulfation, nitration and total acid number. The prerequisite for correct selection of the oil change interval is knowledge on evolution of critical indicators over time. In the reference case, oil oxidation was identified as critical indicator. This knowledge allows to optimize intervals of oil sampling and oil change interval on the basis of time series evaluation.

**Key words:** biogas, engine oil, oxidation, sulfation, oil change.

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## Effects of sulphur on the storage stability of the bio and fossil fuel blends

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**Abstract.** In this study, the aim was to find out if mixing two common fuels together could be beneficial for both the environment and storage stability of fuel. It is obvious, that adding biodiesel to fossil fuel will decrease its sulphur content and reduce its carbon monoxide and hydrocarbon, sulphur dioxide and soot emissions. But will the high sulphur content enhance the storage stability of the biodiesel? Four B20 samples were produced, consisting of 20 vol% biodiesel and 80 vol% fossil diesel. The samples were prepared from rapeseed methyl ester (RME), low sulphuric fossil diesel fuel and high sulphuric diesel solvent. The blends had different sulphur contents of 6, 76, 149 and 226 mg kg<sup>-1</sup>. For these B20 fuel samples, the parameters were compared that correlate with the storage stability of the fuel blends. The studied parameters were the oxidation stability (OSI, according to EN 15751:2015), acid number (AN, according to EN 14104:2003) and kinematic viscosity (KV, by Stabinger SVM 3000 rotational viscometer). The measurements were carried out straight after mixing the blends, and again after 4, 8 and 12 weeks. According to the results, the fuel containing less sulphur slightly lost its oxidation stability within three months. Instead, the oxidation stability of high sulphuric samples improved within the same time frame. As a conclusion, the study gave a reason to assume that – in spite of its known drawbacks – the sulphur may be favourable to fuel blends' storage stability but the phenomenon and chemistry should be studied in more detail.

**Key words:** Biofuel, blending, FAME, diesel fuel, B20, stability, sulphur.

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## Dimethyl ether as a renewable fuel for diesel engines

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**Abstract:** The area of automotive fuel, or fuel components, which can be produced from biomass also includes dimethyl ether, otherwise known as DME. The issue of the use of DME as a fuel is one which has been monitored until recently. Biomass can also be used as the raw material for the production of DME. DME has therefore replaced the previously-used CFCs (chlorofluorocarbons), which are now banned for their role in dangerous levels of ozone depletion. With regard to its physical properties and combustion characteristics, it is currently expected that DME will soon apply significantly as a fuel in the municipal sector and in households, and as an alternative fuel for motor vehicles with diesel engines. DME is a suitable fuel for diesel engines and can be considered as one of the most promising diesel fuel replacements. DME is a suitable fuel for diesel engines mainly due to its low self-ignition temperature and good cetane figures. It is well miscible with most organic solvents and because the polar solvent is water-immiscible. The advantage is its high levels of purity, and its being free of sulphur, nitrogen, or metals. The physical properties of DME are very similar to the physical properties of LPG. DME requires relatively complex and costly fuel accessories, but the original compression ratio of the diesel engine is maintained. A diagram of the fuel system is illustrated in the paper. The paper analyses the dependence of vapour pressure on temperature, the dependence of the density on temperature, kinematic viscosity, the flash point, the boiling point, and the solubility of water. The objective is to evaluate this interesting energy source for applications in diesel engines.

**Key words:** biofuel, biomass, liquefied petroleum gas, vapour pressure, density.

# **X FOOD SCIENCE & TECHNOLOGY**

## Studies of vegetable drying process in infrared film dryer

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**Abstract.** The research work analyzes the two fresh vegetable (carrot and garlic slices) drying process in the infrared film dryer. The energy of infrared radiation penetrates through the material and is converted into heat, and the temperature gradient within the product is reduced in a short period of time. Infrared drying takes place at low temperatures (up to 35 °C) and it helps keep the maximum product quality and natural color. The vegetable drying rate significantly differs depending on the location of the products in relation to the infrared film and product location at the air inlet and outlet. With dried products in 3 parallel shelves the most rapid removal of moisture occurs in the lower shelf (close to the air inlet and film) and the top shelf (close to the air outlet and film). This difference compared to the middle shelf reaches 10–15%. Using the experimental data and multivariate analysis it has been found that the product moisture removal depends on its placement (at the heating film and air inlet, outlet) and the drying time.

**Key words:** IR drying, IR film, carrot, garlic.

## The effects of nitrogen rates and intercropping on the occurrence of *Fusarium* spp. on barley kernels

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**Abstract.** The aim of the field experiments was to compare the effect of nitrogen rates and intercropping on the occurrence of *Fusarium* spp. in barley kernels. The experiments were performed in Central Estonia (58°33'N, 25°34'E) in 2009 and 2010. The composition of fungi in spring barley kernels was found through isolation and subsequent sequence analyses of the internal transcribed spacer (ITS) region and morphological features. During the study, 13 species of micro-fungi were identified in the grain samples. The most common species of fungi found in barley were *Fusarium avenaceum*, *Fusarium poae*, as well as *Phoma pinodella*. The compositions of pathogenic fungi on Estonian barley kernels were affected by the level of nitrogen fertilization and growing on barley-pea intercropping. The study showed tendencies that barley-pea intercropping had fewer occurrences of *Fusarium* species than sole barley.

**Key words:** *Fusarium* spp., spring barley, nitrogen rates, intercropping

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## Development of gluten-free bread with unconventional raw ingredients of high nutritional value and antimicrobial activity

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**Abstract.** Two types of rowan powder (botanical species *Sorbus aucuparia*) as unconventional raw ingredients of high nutritional and biological value as well as three types of dietary fiber and pectin were used in development of gluten-free bread. These raw ingredients have high water-holding capacity and a rich biochemical composition that makes it possible to use them not only as thickeners and structure forming agents, but also as enriching additives. It was experimentally found that the citrus fiber and pectin improved the bread specific volume and the crumb compressibility if compared to the control sample. The content of vitamins A, E, PP, C, B complex, minerals - iron, magnesium, calcium, potassium, selenium, organic acids, including preservatives rendering action (citric, lactic, sorbic, benzoic) were found in rowan powder. It was found that rowan powder and citrus fiber had a significant effect on the increase in the content of dietary fiber in 2.5–5.4 fold and iron in 2–3.5 fold. The content of dietary fiber in bread with 4% of rowan fruit powder is 3.6 g 100g<sup>-1</sup> while in bread with 8% rowan pomace it is 4.3 g 100g<sup>-1</sup>, which corresponds to the dietary fiber daily needs satisfaction respectively by 10.0% and 21.5%. It was found that bread with rowanberry powder had 66.7% more water-soluble antioxidants. The contamination of the main gluten-free raw material (soy protein, rice flour and corn starch extrusion and corn, rowan powder) and its influence on ropy disease of gluten free bread were established. Four spore forming bacteria strains were isolated from gluten-free raw materials and its ability to cause ropy disease of gluten free bread was proved. It was also found that using of rowan powder slow down ropy disease and mold spoilage due to the organic acids in its composition and the bread acidity increase.

**Key words:** Gluten-free bread, rowan powder, quality, nutritional value, antioxidant activity, microflora, microbial resistance.

## Total phenolic content and antioxidant activity of tritordeum wheat and barley

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**Abstract.** Whole grains are a source of numerous antioxidant compounds such as phenolic compounds, anthocyanins, phenolic acids, proanthocyanidins, lignans and others which are able to scavenge free radicals. Thus cereals seem to be very useful in preventing chronic diseases like metabolic syndrome (obesity, high blood pressure, high blood triglyceride and glucose levels), diabetes, neurodegenerative diseases, cancer and chronic inflammatory diseases. Recently, there has been an increased consumer demand for cereal based foods, especially whole cereals. Such demand provides scope for innovations of which an important one is introduction of a completely new cereal cross called tritordeum. This alternative cereal, which is presented as a good source of health beneficial compounds, was assessed in this study and compared with wheat and barley. The total phenolic content (TPC) and related total antioxidant activity (TAA) were investigated via two spectrophotometric methods using a stable 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) and Folin-Ciocalteu reagent respectively. Both TPC and related TAA values of tritordeum and wheat were similar but were significantly lower compared to barley. Results have also revealed a close relationship between TAA and TPC ( $R^2 = 0.93$ ,  $P < 0.05$ ), which might suggest that increased antioxidant activity in those grains is caused by phenolic compounds contained in them. Tritordeum seems to represent a new cereal with good prospects; nevertheless more detailed analysis of its health related compounds is required.

**Key words:** cereals, DPPH, spectrophotometry, total antioxidant activity, total phenolic content, tritordeum.

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## The application of ultrasonic waves for the improvement of particle dispersion in drinks

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**Abstract.** Dispersion is one of the most energy-costly processes in food production. Significant proportions of hard particles remain intact when traditional dispersion methods are used. The intensification of dispersion will lead to the more effective extraction of biologically active components from raw bulk. It will also expedite the ripening of products and will improve their consumer desirability. The goal of this research was to study the dispersing effect of lowfrequency ultrasound (US) on drinks which are of vegetable and animal origin ( $22 \pm 0.6$  kHz). The subjects of the research were raw cow's milk, reconstituted milk, and cranberry drinks which had been produced with the use of traditional technology and employing ultrasonic power. An ultrasonic technological device with an umbrella-shaped working element was used as an ultrasound generator (Russian Federation patent No 2141386). A Nanotrak Ultra analyser (made by Microtrac Inc, USA) was used to study particle size, using the ISO 13321 standard. An analysis of particle size was based on the method which employs the dynamic dispersion of light, in which the minimal detectable particle size is 0.8 nm. It was found that the particles in raw cow's milk, after ultrasonic processing at 180 W for five minutes, decrease in size from  $2,656 \pm 72$  nanometres to a prevailing particle size of  $294.7 \pm 24$  nanometres. Following the US processing of reconstituted milk (with power at 180 W and action time at three minutes), the size of the particles decreases from  $409.5 \pm 62$  nanometres to a prevailing particle size in the range of  $202.2 \pm 41$  nanometres. With the cranberry drink, using ultrasound at 180 W for five minutes caused a decrease in particle size from  $5,670 \pm 62$  nm to a prevailing size of  $1,960 \pm 42$  nm. With an increase in ultrasound power and the duration of the application, an aggregation of particles was noted in both plant and animal-derived drinks. Therefore it can be seen that ultrasound can be used to regulate the dispersion processes in food manufacturing.

**Key words:** milk, cranberry drink, ultrasonic influence, dispersion composition.

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## Functional yoghurt production with oat beta – glucan

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**Abstract.** Nowadays, the importance of functional and nutraceutical food products becomes vital and increases every day, and as yoghurt is one of the most popular and favorite products, we studied the production of nutraceutical yoghurt. We achieved our goal by adding oat Beta–Glucan extract (36% purity) to yoghurt milk at the step of mixing by 0.3% concentration with high agitation till it dissolved and gave its effect in milk then we proceeded to the fermentation to produce yoghurt. As we evaluated the sensory and physical characteristics of yoghurt milk after pasteurization and of yoghurt and recorded the improvement in the characteristics in comparison to others without Beta–Glucan. This evaluation resulted in the fact that the addition of Beta–Glucan decreased the fermentation time, improved the viscosity of yoghurt and the firmness of curd, so it can be used as a substitute of fat and stabilizers. This results in increasing the productivity and the profitability of producers. Finally, the addition of Beta–Glucan as a nutraceutical substance can protect consumers from many diseases such as diabetes mellitus and atherosclerosis.

**Key words:** Nutraceutical yoghurt, Oat Beta–Glucan (36%), fat substitute, improving productivity.

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## Improvement of microbiological safety and shelf-life of pulse spreads through *sous vide* and high pressure processing

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**Abstract.** Microbiological quality of *sous vide* treated (80 °C/15 min) and high pressure processed (700 MPa/10 min/20 °C) cowpea (*Vigna unguiculata* (L.) Walp. cv. Fradel) and maple pea (*Pisum sativum* var. *arvense* L. cv. Bruno) spreads in flexible vacuum packaging during 62- day storage at 5 ± 1 °C were assessed. Pulse spreads, made from cooked pulses with salt, citric acid, oil, and seasoning, were filled in PA/PE or PET/ALU/PA/PP flexible film pouches, packaged in vacuum (20 mbar) and hermetically sealed. Microbiological testing was performed by determining total plate count, yeast and mould count on days 0, 15, 29, 42, 50, 57, and 62, and the presence of *B. cereus*, *C. perfringens* and *E. coli* before processing and after 62-day storage. The results showed that total plate count increased significantly after 62-day storage in both *sous vide* ( $P = 0.011$ ) and high pressure processed ( $P = 0.017$ ) spreads; the observed over one-log increase was without significant differences between pulse spreads and packaging materials ( $P < 0.05$ ). The admissible level of total plate count ( $N_{max} < 3.69 \log\text{CFU g}^{-1}$ ) in pulse spreads was not exceeded. The presence of yeasts and moulds, *C. perfringens* and *E. coli* in pulse spreads was not confirmed, whereas *B. cereus* accounted to  $<10^2 \text{CFU g}^{-1}$  after 62-day storage. The suggested shelf-life of processed pulse spreads is 62 days; except for *sous vide* treated spreads with seasoning in both packaging materials- 57 days. Both processing methods are suitable to ensure the production of high quality pulse spreads with adequately long shelf-life.

**Key words:** cowpea, maple pea, microbiological quality, pathogens, flexible packaging.

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## Comparison of methods of extraction of phenolic compounds from American cranberry (*Vaccinium macrocarpon* L.) press residues

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**Abstract.** American cranberries (*Vaccinium macrocarpon* L.) contain significant quantities of various phenolic compounds. Most of these compounds are recovered when berry juice is produced. However, a considerable part of polyphenols remain in berry press residues and are discarded as food industry waste. The aim of the study was to compare the methods of extraction of polyphenols (ultrasound, microwave-assisted, Soxhlet) from press residues of American cranberry. The impact of main extraction parameters (e.g., extraction time, solid/solvent ratio, solvent type) on the yield of extracted polyphenols. Ultrasound-assisted extraction showed the highest potential from all studied methods, given its fast, convenient use and low cost. Aqueous ethanol and methanol in the presence of acid (anthocyanin extractions should be assisted with trifluoroacetic acid, polyphenol extractions – with HCl) were assessed as the best solvents for extraction. The obtained extracts were characterised using the Folin-Ciocalteu method for determination of total phenolics and the pH-differential method for determination of total anthocyanins, and UPLC–PDA was used to determine the content of individual anthocyanins. Cyanidin-3-*O*-arabinoside, peonidin-3-*O*-galactoside, peonidin-3-*O*-glucoside and peonidin-3-*O*-arabinoside were identified as the main anthocyanins in cranberry press residue extracts.

**Key words:** phenolic compounds, antioxidant activity, flavonoids, anthocyanins, *Vaccinium macrocarpon*, press residues .

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## Meat industry by-products for berry crops and food production quality improvement

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**Abstract.** This paper describes the problem of obtaining a hydrolysate from animal industry by-products. A new innovative protein-containing product has been created to stimulate the growth and development of berry and fruit crops. The paper describes a technique for a plant treatment with a hydrolysate invented, its concentrations being determined. We have studied the chemical composition of fruit and berry raw materials in a native form after rapid freezing and refrigeration. The possibility of creating a new confectionery product made from quick-frozen berries treated with a stimulator is predetermined.

**Key words:** protein hydrolysate, stimulator of plant growth and development, quick-frozen berries, anthocyanins.

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## A study of factors which influence mould spoilage in flat (sourdough) bread

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**Abstract.** Bakery products are an excellent substrate for the development of microbial spoilage, especially mould spoilage and lime disease (otherwise known as chalk disease), because they have high levels of water activity  $a_w = 0.94-0.97$  and pH 5.5-6.0. Sliced bread in its packaging is highly susceptible to moulds and lime disease during storage. The aim of this study was to investigate the effects shown by the microbial contamination of flour quality, and the type of sourdough and organic acid, especially acetic acid, on mould spoilage in wheat and rye wheat bread. Microbial contaminations were studied in two batches of wheat flour and three batches of rye flour which had been manufactured in Belarus and Russia and in sourdough bread which had been produced using this flour. Investigated here was the impact of the quality and type of sourdough with various starter cultures of micro-organisms and the impact of the content of organic acid, especially acetic acid, on mould spoilage in wheat and rye wheat bread. The content of organic acids, including acetic acid, in different types of sourdough which has been prepared using different starter cultures and in different kinds of sourdough bread which have been studied using liquid chromatography. It was found that, in spite of the presence in flour of spore-forming bacteria, yeasts, and fungi, microbial contamination of the finished product immediately after baking was absent. It was proven that the use of starter cultures and sourdough can slow down or prevent entirely the microbial spoilage of bread. It was found that the content of acetic acid which had been accumulated during the fermentation of various types of sourdough served to effect the presence of mould spoilage on sourdough bread.

**Key words:** sourdough, bread, microbial contamination, mould, microbial spoilage

## Possibility of using reconstituted milk in manufacture of cheese with cheddaring and cheese curd stretching

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**Abstract.** The use of reconstituted milk may significantly increase the possibility of cheese manufacture and limited irregular milk supplies for cheese making plants. Data collecting and analyzing revealed that there are cheese technologies with cheddaring and cheese curd stretching accompanied by partial replacement of natural milk by reconstituted. Therefore, the aim of this research is to develop the technology of cheese with cheddaring and curd stretching made from reconstituted milk as the main raw material. A comparative study of physicochemical characteristics of five dry milk powder samples obtained from different producers and natural milk has been carried out. The choice of reconstituted skimmed milk as the raw material is explained; its quality is assessed and the process parameters of milk reconstitution are chosen. It is recommended to combine holding of reconstituted skimmed milk and milk ripening. Cheddaring is known to be a fairly time-consuming process, the use of starter cultures during reconstituted milk ripening can intensify this process. The process of milk ripening has been carried out at 16 °C for 10 h using the manufacturer's recommended dosages of starter cultures. The best results have been obtained when Lyofast MOT 092EE is used. Milk ripening is found to be a very important operation for the production of cheese with cheddaring and cheese curd stretching made from reconstituted milk.

**Key words:** cheese, pasta filata, reconstituted skimmed milk, stretchability, meltability.

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## Development of a rapid method for determination of gluten content in wheat flour

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**Abstract.** Gluten content is one of the most important factors of the quality of wheat flour. Bread price depends on the quality and quantity of gluten. For the professionals of baking industry it is important to quickly and efficiently determine gluten content in wheat flour. Gluten content is commonly defined by manual or automated washout. The present study aimed to develop a rapid method for determination of gluten content in wheat flour by electrophysical method and compare it with the other standard methods (ISO 21415–1:2006, ISO 21415–2:2015). The method is based on determination of permittivity of flour, which varies depending on the amount of free water produced by heating and correlated with the content of gluten. The methodology of research included the use of wheat flour samples (gluten content in the range of 23.0% and 32.0% and flour humidity to 15.0%). The heating temperature of the analysed flour samples was in the range of 30 °C and 70 °C. Mathematical processing of the results of the experiment allows to establish the relationship between gluten content and capacitance of flour. The proposed method makes it possible to reduce the time of analysis by reducing the number of operations within the analysis and the influence of subjective factors comparing to manual and automatic washing method a gluten flour (ISO 21415–1:2006, ISO 21415–2:2015).

**Keywords:** gluten content, rapid determination, permittivity.

## The Effects of Various Raw Ingredients on Bread Quality

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**Abstract.** The purpose of the current research is to study the mechanisms behind how various raw ingredients affect the quality of bread. The objects of the research were the flour used in making the bread (consisting of gluten at 28.5%, and with an ash content of 0.55), with no added fats; tap water or activated water (treated in a USTA-0.4/22 OM ultrasonic processor (Volna, Russia), operating at a frequency of  $22 \pm 1.65$  kHz and at 30% of maximum output power (400W) for mixing dough); and plant extract additives based on stevioside and fucoidan (fully replacing the sugar). Included in the analysis were the effects of using activated water and combined plant extract additives on organoleptic qualities (appearance, crust colour, crumb condition, taste, stickiness during mastication, and friability), as well as the physical and chemical qualities (moisture content, porosity, and acidity). Yeast activity was studied in dough which had been produced using activated water and combined plant extract additives. An Altami-136T optical microscope (Altami, Russia) was used to study the activity of yeast cells. The effects of activated water and combined plant extract additives were analysed by examining the microstructure. Microscopic studies were carried out using a Jeol JEM-2100 electron microscope (Jeol Ltd, Japan). The results confirm that activated water and combined plant extract additives may be used to improve the quality of fresh bread.

**Key words:** bread, bakery products, activated water, sweeteners, bound water, storage.

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## A Study of the Forms of Bound Water in Bread and Bakery Products using Differential Thermal Analysis

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**Abstract.** The objective is to study the forms of bound water in bread and bakery products using differential thermal analysis, changes to these forms corresponding to different recipe components, and changes occurring during storage. The subject of this research are bread and bakery products made of wheat flour (with gluten content of 28.5%, and ash content of 0.55%): without added fat; with tap water or activated water used for dough mixing; with varying fat content (4 and 14%); protein-enriched with cedar nut flour (5%); and dietary (food) fiberenriched with red-fruited mountain ash and sea buckthorn powder (5%). The reference samples of bread and bakery products were stored in plastic film bags at  $20 \pm 2$  °C for a period of 72 hours. The freshness was monitored by changes in the physical-chemical parameters (moisture content, swelling capacity, friability). The various forms of bound water were determined using the method of differential thermal analysis on a simultaneous TGA-DTA/DSC thermogravimetric analyzer, with a programmable temperature regime. Based on the obtained digital data on thermogram (TG) change, using Pearson's criterion, a mathematical model has been created to identify the linear sections with a different inclination angle which are characterized by a constant rate of water removal. For all studied samples of bakery products, 6 linear sections were identified, but statistically significant results were obtained for sections III, IV and V, with the exception of section III for bakery products with cedar flour. Use of activated water, fat, and additives of cedar flour, powders of red-fruited mountain ash and seabuckthorn in the production of bread and bakery products leads to redistribution of water forms, which is confirmed by changes in the boundaries of the linear sections, both for freshly made products and for products after storage. As a result, these products stay fresh longer.

**Key words:** bread, bakery products, activated water, powder, bound water, storage.

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## **An investigation into the effects of bioactive substances from vegetable oils on the antioxidant properties of bakery products**

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**Abstract.** This article discusses ways in which the antioxidant capacity of bakery products (otherwise referred to as 'BPs') can be increased by adding various types of vegetable oil to the dough: chosen as test oil was unrefined rice bran oil, unrefined pumpkin seed oil, and refined and deodorised sunflower oil. The authors conducted a study of fatty acid compositions and biologically active substances to be found in vegetable oils. The antioxidant properties of vegetable oils were analysed according to the following characteristics: the formation of the primary (peroxide value) and secondary (anisidine value) oxidation products; the oxidation coefficient (IR spectroscopy) which can be determined in the process of applying thermal treatment (with five hours of heating at 120 °C), which leads to the Vitamin E being destroyed. The biochemical composition of vegetable oils affected their resistance to the thermal oxidation process in the following sequence: unrefined rice bran oil > unrefined pumpkin seed oil > refined and deodorised sunflower oil. BPs were made from wheat flour dough with the addition of 4% of the corresponding vegetable oil and 5% of sugar, and were baked at two temperature regimes: at 200 °C and at 220 °C. The antioxidant activity of the BPs was determined by means of two methods: by chemiluminescence, and by DPPH radical assay. The antioxidant activity of the BPs varies depending on the vegetable oil being used, with the differences being revealed in the following way: BPs with unrefined pumpkin seed oil > BPs with unrefined rice bran oil > BPs with refined and deodorised sunflower oil. Any increase in the baking temperature reduced the antioxidant activity of the BPs; the antioxidant properties in the crust and the crumb were reduced at differing rates.

**Key words:** sunflower oil, rice bran oil, pumpkin-seed oil, bioactive substances, bakery products, antioxidant properties

## The influence of $\kappa$ -casein genotype on the coagulation properties of milk collected from the local Latvian cow breeds

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**Abstract.** Cheese production is becoming increasingly more diversified all over the world. The information on milk coagulation properties among Latvian dairy cow breeds and its suitability for cheese production still remains unclear. At the same time, milk with good renneting properties collected from the native Latvian cows can be used for the production of Protected Denomination of Origin (PDO) cheeses. The purpose of this research was to analyse the influence of the milk protein genotypes present in Latvian native cattle breeds on the milk coagulation properties. The Data was collected in 2016 from 56 Latvian brown, 26 Latvian blue and 13 Holstein black and white cows. Highest frequency of AA  $\kappa$ -casein genotype was found in Latvian brown breed (0.593), while AB genotype was more often present in the Latvian blue breed (0.636). It has been found that the presence of  $\kappa$ -casein genotype resulted in no significant difference in milk composition and milk coagulation properties among studied cattle breeds. We have observed a tendency that the most desirable milk coagulation properties were present in BB genotype. A significant effect of breed on milk composition has been found ( $p < 0.05$ ). Milk yield of Holstein Black and White was  $32.0 \pm 2.99$  kg, while in Latvian blue it was only  $17.6 \pm 1.32$  kg. Higher milk yield was obtained in Latvian blue breed in comparison to that of the brown breed –  $19.10 \pm 0.76$  kg. Better milk coagulation properties were observed in Latvian brown breed – shorter milk renneting time ( $16.86 \pm 1.15$  min), highest curd yield ( $24.0 \pm 0.79\%$ ) and curd firmness ( $3.21 \pm 0.17$  N).

**Key words:** Latvian brown cows, Latvian blue cows, milk coagulation properties

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## Selected wastewater parameters from the vegetable washing process

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**Abstract.** This article follows selected parameters in wastewater which arise from the washing process for root vegetables, which is one of those problems which are current in terms of water usage. With a growing population, industrialisation, and urban development, there is also a growing demand for water resources. Industries which are dealing with the processing of agricultural products and food production in general significantly contribute to the growing consumption of water. Technology which is used for cleaning vegetables also significantly affect this growth in water consumption. Increasing demands on the quality of vegetables (eg. the cleanliness of vegetables at the point of sale), also leads to the necessity for more effective post-harvest cleaning, something which is carried out both with dry and wet methods. This article examines the cleaning process for selected root vegetables, particularly carrots and potatoes, by determining selected properties of the output process water in an assessed technological line. This line is specific with regard to its methods for cleaning carrots and potatoes. Following the investigation, the line was assessed as being satisfactory with respect to the quality of the input and output water. The monitored parameters of the process water (eg. concentrations of selected elements in the process water and concentrations of selected inorganic anions in the process water, mainly Na and Pb) from cleaning carrots and potatoes were considered as being satisfactory for recirculation into the cleaning process and therefore a reduction was achieved in overall water consumption.

**Key words:** food industry, technological line, vegetables, washing vegetables, wastewater.

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