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THE IMPORTANT ROLE OF RETROFITTING IN AGRICULTURAL MACHINERY: A CASE STUDY FOR TECHNIQUES AND APPLICATIONS*

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ВАЖНОСТЬ МОДЕРНИЗАЦИИ В СЕЛЬСКОХОЗЯЙСТВЕННОМ МАШИНОСТРОЕНИИ: ТЕМАТИЧЕСКОЕ ИССЛЕДОВАНИЕ ТЕХНИКИ И ПРИЛОЖЕНИЙ

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ВАЖЛИВІСТЬ МОДЕРНІЗАЦІЇ У СІЛЬСКО-ГОСПОДАРСЬКОМУ МАШИНОБУДУВАННІ: ТЕМАТИЧНЕ ДОСЛІДЖЕННЯ ТЕХНІКИ ТА ВИКОРИСТАНЬ

Abstract. The article provides a comparative analysis of important role of retrofitting in agricultural machinery. Over the last fifteen years, many new technologies have been developed for, or adapted to, agricultural use. Examples of these include: low-cost positioning systems, such as the Global Positioning System, proximal biomass and Leaf Area Index (LAI) sensors mounted on-board agricultural machinery, geophysical sensors to measure soil properties and low-cost, reliable devices to store and exchange/share the information. Combined, these new technologies produce a large amount of affordable high resolution information and have lead to the development of fine-scale or site-specific agricultural management that is often termed Precision Agriculture. Farming moves into the 21st century with tractors carrying satellite navigation receivers, radar guns, and computers. socio-agricultural systems and, as a consequence, adopters are currently becoming more and more complex in current economies and it might prove difficult to analyse patterns and forecast trends. The conclusions of this study are of course tentative. Hence, there is need for much more detailed research and analysis concerning the attitudes of adopters of innovations in agricultural tractors, in particular in the presence of fast-changing scenarios due to a more and more acceleration of technological change.

Keywords: precision agriculture, retrofitting of agricultural machinery, retrofitting, innovation in agricultural machinery.

Introduction

Technological innovation plays a major role in agricultural systems. In particular, agriculture industry has had exceptional advances and application of new technologies, revolutionising the farming [4, 20]. Technological innovations are largely applied to agricultural tractors, enabling more efficient production and use of energetic resources, associated to both lower environmental impact and improvement of drivers' working conditions [13]. In fact, the tractor has a central role in farm operations and remains the most important and widespread path-breaking machine in agriculture [12]. It pulls, lifts, powers, supports and is often the main status symbol of the agricultural

Статья посвящена 95-летию со дня основания Днепровского государственного аграрно-экономического университета enterprise. Moreover, it is common to find individual farmers faithful to one particular brand. Of course the technology incorporated in a tractor has a considerable influence on production costs and, as a consequence, on retailer price [24]. The demand for agricultural machinery strongly depends on farm income, which is influenced by external variables such as agricultural policy, socio-economic environment, people's attitudes, weather and public policies [23].

As farming moves into the 21st century with tractors carrying satellite navigation receivers, radar guns, and computers, the urge of farmers to retrofit existing equipment to save money and perhaps do the job better is infectious. It spreads to private industry and government representatives who work with farmers. From this interchange, new farm equipment is born. Precision agriculture means farming with on-the-go monitoring of yields and soil types, as well as of chemical and manure applications. Global Positioning System (GPS) satellites are used to spatially locate tractors and other farm equipment in a field.

Over the last fifteen years, many new technologies have been developed for, or adapted to, agricultural use. Examples of these include: low-cost positioning systems, such as the Global Positioning System, proximal biomass and Leaf Area Index (LAI) sensors mounted on-board agricultural machinery, geophysical sensors to measure soil properties and low-cost, reliable devices to store and exchange/share the information. Combined, these new technologies produce a large amount of affordable high resolution information and have lead to the development of fine-scale or site-specific agricultural management that is often termed Precision Agriculture (PA) [2, 3].

The four PA technologies include location determination (via the Global Positioning System, GPS), computerized geographic information systems (GIS), computer-guided controllers for variable rate application (VRA) of crop inputs, and sensing technologies for automated data collection and mapping. The GPS and GIS technologies underpin both of the major PA practices that farmers have begun to adopt [12].

Several generations ago farmers relied on tools such as almanacs and the phases of the moon to estimate when to begin planting. Today these tools are supplemented with space age technologies that allow the farmer to raise their crop in more precise and efficient ways. Some of these technologies include global positioning systems, geographic information systems, yield mapping, variable-rate technology, and remote sensors. Precision farming (the art of using these technologies to increase yields and profits while protecting the environment) is becoming more prevalent in farming operations. There is a need in the farming community for tools that provide the farmer easy access to these technologies while avoiding cumbersome data gathering systems, information overload, or burdensome application equipment.

The economic theory of induced innovation predicts that new technologies will be developed and adopted where they make more efficient use of the scarcest productive resources. Indeed, adoption of precision agriculture technologies has been fastest where labor is costly but land and capital are relatively less costly. Where precision agriculture is being adopted, the uneven adoption rate is tied to normal cycles for replacing the expensive machinery in which many precision agriculture technologies are embodied. Equipment replacement decisions are affected by many factors exogenous to the farm, such as bank interest rates and commodity prices. Adoption is likely to continue in labor-scarce, landabundant countries, with rates of adoption accelerating when commodity prices are high and interest rates low [12].

Previous studies

Don Comis et al. made the tractor typifies space-age agricultural tools: It sports a roof antenna for satellite signals, a GPS receiver in the cab, and a radar gun below the cab's floor, to monitor ground speed. Shirley heads a team of eight who form the land operations branch for the east section of the 7,000-acre research farm. They are essentially the farmers who see that the crops get planted and the machines work. Shirley and other crew members use the equipment to make the center's farming more sustainable economically and environmentally. The gear is also used in BARC's precision farming projects, The center has a variable-rate liquid manure applicator thanks primarily to crew member John Bouma, nicknamed "The Fabricator". Bouma also devised one of the few silage harvesters in the world with on-the-go yield monitoring. Rockwell International gave Bouma a GPS receiver and computer and a pair of light-beam sensors. [5].

Bruno Tisseyre et al. made a brief review of sensing systems, methods and tools dedicated to

PV. In a relatively short time, technologies and methodologies to collect and analyse high resolution data on vine characteristics, soil and environment properties, grape yield and grape quality have become a reality. These information sources provide accurate spatial information about variability in viticulture production systems. They will allow growers and viticulturists to consider new management methods, more efficient experimental designs and provide a better understanding of the vine production system [21].

Zhang et al. provided an overview of worldwide development and current status of precision-agriculture technologies based on literatures generated mainly during the 2000-2002 years. The topics include natural-resource variability; variability management; management zone; impact of precision-agriculture technologies on farm profitability and environment; engineering innovations in sensors, controls, and remote sensing; information management; worldwide applications and adoption trend of precision-agriculture technologies; and potentials of the technologies in modernizing the agriculture in China [23].

Rude D. et al. initiated a project in Canada with the primary goal of conducting two engineering initiatives to improve the safety of used agricultural equipment. They implement that injuries from agricultural machinery occur at a very high rate, and most of these injuries are caused by used equipment and despite engineering of safer equipment being one of the preferred means to reduce injuries, there currently is limited engineering effort applied to the safety of used machinery [19].

Birkeland Janis stated that as all environmental problems are caused by human systems of design, sustainability can be seen as a design problem. Given the massive energy and material flows through the built environment, sustainability simply cannot be achieved without the re-design of our urban areas.

"Eco-retrofitting" means modifying buildings and/or urban areas to create net positive social and environmental impacts – both on site and off site [1].

Matthew O. Anderson et al. developed a team of autonomous robotic vehicles applicable to precision agriculture in The Idaho National Engineering and Environmental Laboratory (INEEL) and Utah State University's Center for Self-Organizing and Intelligent Systems (CSOIS). They have generated a unique technique to plan, coordinate, and optimize missions in large structured environments for these autonomous vehicles in real-time. Two generic tasks are supported: 1) Driving to a precise location, and 2) Sweeping an area while activating on-board equipment. Sensor data and task achievement data is shared among the vehicles enabling them to cooperatively adapt to changing environmental, vehicle, and task conditions [14].

Ferrari E. et al. have analysed the attitude and opinion of a sample of Italian users of agricultural tractors, concerning some innovations, to outline different profiles of behaviour in three separate groups of adopters of agricultural tractors by their attitude towards technological innovations in these vital machines: the "Unwilling" users, neither use innovative tractors, nor would like to have tractors equipped with new technological innovations, the "Willing-Cultural" users have traditional machines but would like to have innovative tractors in the future, and the "Innovative-Owner" adopters have and use ground-breaking tractors [8].

Capacci E. et al. evaluated the applicability of the tractor OECD ROPS Codes 4 and 8 to rollover protective structures retrofitted on in-use grape harvester was performed and the strength test results are presented and discussed according to fatalities and serious injuries resulting from rollover accidents involving tractors and self-propelled agricultural machinery [10].

Mahalik N.G.P.C and friends presents work on retrofitting of high-tech systems (HTS) in land-based aquaculture system for improving production efficiency [11].

Baker W. et al. identifies individual and machine characteristics that are associated with an increased risk of a serious farm work related injury. A comprehensive analysis of a series of farm machinery events is reported, and through the application of a human factors and systems approach, recommendations are made in relation to improving machinery design to reduce the potential for injury events to occur, and to reduce the severity of resulting injury when such events do occur [13].

Drenjanac D et al. different localization techniques for a human operator and an autonomous tractor in a field environment were tested. First, we compared the localization performances of two global navigation satellite systems (GNSS) receivers carried by the human operator: (1) an internal GNSS receiver built into a handheld device; and (2) an external DGNSS receiver with centimeter-level accuracy. To investigate autonomous tractor localization, a real-time kinematic (RTK)-based localization system installed on autonomous tractor developed for agricultural applications was evaluated. Finally, a hybrid localization approach, which combines distance estimates obtained using a wireless scheme with the position of an autonomous tractor obtained using an RTK-GNSS system, is proposed [14].

Agricultural sector

The agricultural sector is characterized by heterogeneous machinery, large numbers of process partners as well as high machine operating costs. Inefficiencies in agricultural processes arise from idle times, e.g. when transport vehicles are waiting for operation or when the processes halt because of improper planning. Other causes for inefficiencies are non-optimal allocations of machinery. These process inefficiencies may cause high, but avoidable costs.

The placement of fleet automated technology in the agroforestry sector may provide a number of benefits, including; 1) reducing environmental contamination from excessive agrochemical applications by adopting Global Navigation Satellite System (GNSS) based site-specific application techniques, 2) increasing yields by optimizing site-specific input application levels and 3) decreasing necessity of skilled farm laborers required to perform agricultural tasks. An autonomous agricultural vehicle requires a combination of several techniques (sensors, machine vision techniques, etc.) including GNSS. For real-time applications that require on-the-go corrections, a differential GNSS technique (DGNSS) is preferred to achieve very high location accuracy. As the resolution at which the geoposition improves, it increases the number of plant-specific management tasks suited for automation. A straightforward method to achieve accurate geopositioning is to use two GNSS receivers (a rover and a base) that track the same satellites. In this case, the position of the base (a stationary unit) can be accurately determined using satellite signals. The location information from the base can be used to correct the location of the rover, and this correction information can be communicated to the field GNSS receiver by a radio link [11, 17]. This method allows for minimization of error and higher real-time accuracy [13]. In today's agricultural processes, RTK-DGNSS (Real Time Kinematic-Differential GNSS) based auto steering provides substantial savings in agro-chemicals and reduced hand-weeding requirements, with the associated environmental and economic advantages [10, 2, 9]. Although the use of two GNSS receivers requires a significant financial investment, RTK-GNSS systems are becoming increasingly common among commercial farming operations for automatic steering of tractors and other types of field equipment. One disadvantage of using RTK-GNSS solutions in agriculture is the requirement that a base station be located within 10 km at all times, and this results in high capital cost. Multiple reference station RTK trials have been ongoing since the late 1990's [16].

Conclusion and discussion

The past decade has led to the development of sophisticated technology based on electronics across all fields of agricultural machinery. The analysis of technological innovations of tractor is paramount to those agricultural machinery stakeholders who are looking for new market opportunities to increase their turnover and expand their business in competitive markets, as well as to those who are responsible for the agricultural policy regulations of countries.

Comfort and safety of agricultural tractors are the two technological features that have received much attention from users and where manufacturers should direct their efforts in developing fruitful technological trajectories in a not-too-distant future.

There is a need for much more detailed research and analysis, in the presence of current market turbulence and fast-changing technology, to detect evolutionary fruitful technological trajectories of agricultural tractors to increase efficiency and safety in the agricultural systems, adopting, at the same time, the principles of precision agriculture. [15].

The other important problem for agricultural machinery is the finance of retrofitting and high technological systems for precision farming or another high level system for farming. The ratio of using technology will be determined by farmer's financial opportunities and bank rates.

Every new attempt on upgrading technology on farming will be faced on resistance in people mind. "While traditional or present technologies gives a certain amount of profit why need for give extra money for new technologies?" This question is frequently asking today. In contribution to farmer resistance, governments and universities should be continued to force farmers to upgrade their farming techniques and machinery. Because, agriculture is not a local application in a certain place or not a personal application for continue life today. Farmer choices will affect the future of whole country and also whole earth policy on agriculture. Therefore, countries making arrangements on agriculture and related industries for achieve more gain per unit area.

There is another problem is educated personal needing in retrofitting agricultural machinery. In addition to expert person requirement, services should be upgraded for new technological retrofitting operations on old fashioned agricultural machinery. That chain effect will improve other related industries in time and agriculture will determine the new demands on industry as always.

Against all problems technological developments will affect the agricultural machinery technology and precision agriculture and remote control systems will be play a role in the future agriculture.

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Аннотация. В статье приведены результаты сравнительного анализа по поводу важной роли модернизации сельскохозяйственной техники. За последние 15 лет было разработано и адаптировано много новых технологий для использования в сельском хозяйстве. К примеру, системы глобального позиционирования (GPS), датчики биомассы и анализаторы лиственной поверхности (LAI), установленные на борту сельхозтехники, геофизические датчики для измерения свойств грунта, а также недорогие, но надёжные устройства для хранения и обмена информацией. В совокупности эти новые технологии производят большое количество доступной информации с высоким разрешением и приводят к развитию точного земледелия. Сельское хозяйство переходит в 21-м веке на тракторы с устройствами спутниковой навигации, радарами и компьютерами, и, как следствие, социо-аграрные системы становятся всё более и более сложными для анализа структурных изменений и прогнозирования тенденций. Исследования в указанном направлении развиваются, следовательно, существует необходимость в более детальных исследованиях и анализе, который касается внедрения инноваций для сельскохозяйственных тракторов, в частности, в условиях быстро изменяющихся сценариев, из-за всё большего ускорения технологических изменений. Существует необходимость в намного более детальных исследованиях и анализе в условиях текущей рыночной турбулентности и быстро изменяющихся технологий. Есть ещё одна проблема – потребность в образованных специалистах для модернизации сельскохозяйственной техники. Кроме того, экспертно-консультационные услуги тоже должны быть приспособлены к потребностям и задачам переоборудования сельскохозяйственной техники.

Ключевые слова: точное земледелие, модернизация сельскохозяйственной техники, модернизация, инновации в сельскохозяйственной технике

Анотація. У статті наведено результати порівняльного аналізу щодо важливої ролі модернізації сільськогосподарської техніки. За останні п’ятнадцять років багато нових технологій були розроблені або адаптовані для сільськогосподарського використання. Зокрема, системи глобального позиціонування (GPS), датчики біомаси та аналізатори листкової поверхні (LAI), встановлені на борту сільгосптехніки, геофізичні датчики для вимірювання властивостей ґрунту, а також недорогі, але надійні пристрої для зберігання і обміну інформацією. У сукупності ці нові технології виробляють велику кількість доступної інформації з високою роздільною здатністю і приводять до розвитку точного землеробства. Сільське господарство переходить в 21-му столітті на трактори з пристроями супутникової навігації, радарами і комп’ютерами, і, як наслідок, соціо-аграрні системи стають все більш і більш складними для аналізу структурних змін та прогнозування тенденцій. Дослідження за вказаним напрямком розвиваються, отже, існує необхідність в більш детальних дослідженнях і аналізі, що стосується впровадження інновацій для сільськогосподарських тракторів, зокрема, в умовах швидко мінливих сценаріїв, через все більше прискорення технологічних змін. Існує необхідність в набагато більш детальних дослідженнях і аналізі в умовах поточної ринкової турбулентності і швидко мінливих технологій. Є ще одна проблема – потреба в освічених фахівцях для модернізації сільськогосподарської техніки. Крім того, експертно-консультаційні послуги теж повинні бути пристосовані до потреб і завдань переобладнання сільськогосподарської техніки.

Ключові слова: точне землеробство, модернізація сільськогосподарської техніки, модернізація, інновації в сільськогосподарській техніці

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