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Conclusions and Recommendations

"The 25 years of the Club of Bologna - Evolution and Prospects of Agricultural Mechanization in the World"

CONCLUSIONS AND RECOMMENDATIONS

by ***Luigi Bodria*** *(Honorary President of the Club of Bologna) and* ***Marco Fiala*** *(Secretary General of the Club of Bologna)*

Luigi Bodria, President of the Club of Bologna, **63 experts** from 20 Countries and **9 Representative of an International Organization** (FAO, UNIDO, EurAgEng, CEMA, Accademia dei Georgofili, UNASA) took part at the 26th Meeting of the Club of Bologna ***"The 25 years of the Club of Bologna - Evolution and Prospects of Agricultural Mechanization In the World"***, held on 12 and 13 November 2016 in Bologna (Italy), on occasion of EIMA International 2016.

The meeting was dedicated to the celebration of two important events: the signing of a **cooperation agreement between FerderUnacoma and Accademia dei Georgofili,** who joined CIGR, FAO and UNIDO as a support institution to activities of the Club of Bologna and the **25th anniversary of the Club of Bologna** with the presentation of a special volume on the ***"Evolution and Prospects of Agricultural Mechanization in the World"*** which provides a complete and comprehensive picture of the situation of mechanization in the different world regions.

In the Session 1 – **Memorandum of Understanding FederUnacoma and Accademia dei Geogofili** the cooperation agreement between FerderUnacoma and Accademia dei Georgofili was introduced by the President of FederUnacoma, Massimo Goldoni, and the Vice President of the Accademia dei Georgofili, Pietro Piccarolo. The two speakers recalled the long tradition of scientific cooperation between the two organizations and their common commitment to the development of agriculture and pertinent technological innovation. On behalf of their respective organizations, they signed a Memorandum of Understanding for the promotion of joint activities addressed to the progress of mechanization, environmental protection and food quality and safety.

In the Session 2 – **The 25 Years of Club of Bologna** the authors who have collaborated in the preparation of the volume presented their Keynote Reports.

The first introductory Keynote Report "**The 25 Years of Club of Bologna**", by Luigi Bodria and Marco Fiala (University of Milan, Italy) and Karl T. Renius (Technischen Univ. München, Germany), recall the genesis and development of the Club from the first preparatory meeting of the founding committee until the Open Meeting at Expo 2015 in Milan.

In the Session 2 – Part 1 the mechanization of highly industrialized areas was considered.

The Keynote Report "**Agricultural mechanization and the Role of Tractors**", by Karl T. Renius (Technischen Univ. München, Germany) emphasizes the key role of the tractor for the development of agricultural mechanization in its different functions: classic for food production, environmental for landscape maintenance and strategic in order to free labour power other economic areas indicating strategies and methods for worldwide tractor development. Then the author describes the major strategies for worldwide tractor development introducing as well the innovative ideas for future tractors.

The Keynote Report "**Agricultural Mechanization in Europe**", by Peter Schulze Lammers (University of Bonn, Germany), Milan Martinov (University of Novi Sad, Serbia), Emmanuel Hugo (Irstea, France), David Tinker (EurAgEng, United Kindom), Stefan Böttinger (University of Stuttgard, Germany) give a comprehensive overview of European agriculture that resulted in an important economic turnover of 211.9 billion Euro in 2015. Standardization has an important role in agricultural machinery sector in Europe. The EU published in 1974 the first directive on tractors

and the European Committee for Standardization (CEN) now has 33 members setting up new standards as well as updating existing standards.

The Authors underline how in the recent years the *Common Agricultural Policy (CAP)* has been a major topic of European policy with increasing attention to environmental concerns. The traditional tillage is widely used but there is rising interest in the non-conventional tillage systems in order to reduce costs and improve soil structure and fertility.

A very critical sector is plant protection in which estimates indicates that more than 50% of the applied pesticides are not effective so research focuses on improving application efficiency. Sensors based on lasers, ultrasonics, visible light with cameras as well as infrared systems have been developed to reduce pesticide use by target spraying in orchards. Sprayers are equipped with several sensors which control nozzles with regard to non-uniform tree distances, missing trees and tree height.

Particular interest is devoted to energy efficiency in agricultural production - reduction in energy input contributes to a decrease in use of fossil fuel, costs and a saving of greenhouse gases - as well as to Renewable Energy Sources (RES), following the directions of EU RES Directive 2009/28/EC.

Current research and future development mainly concern precision crop and livestock farming in order to better adapt machine action to crop/animal needs and local condition. Major technologies are: geographical information systems, location systems, sensors dose control device and performances measurement systems. Next step will be towards the autonomous machines but still questions arise on the future of robotics in agriculture with different opinions among the authors.

The Keynote Report "**Agricultural Mechanization in the United States of America**", by John K. Schueller (University of Florida, USA) presents the mechanization in the world's largest country with an area of almost ten million square kilometres which it took place one of the most important steps in the popularization of tractors when Henry Ford marketed the tractor Fordson in the latter part of World War I. Then the agreement between Henry Ford and Harry S. Fergusson regarding the three-point hitch system contributed to the diffusion of use of tractors with a peak manufacturing of tractors after the World War II.

Although the use of utility tractors in the 40-100 HP power range is the most common there is an increasing development of articulated tractors of about 300-600 HP for the largest farms. The use of electronics has largely developed and the original "islands of automation" have evolved and the various electronic systems are now being networked together. For the future increasing number of Continuous Variable Transmissions (CVT) and rubber tracks are expected as well as more use of electricity to power auxiliary drives. There will be also much greater automation in order to optimize field operations and operate at optimal points engine, transmission and auxiliaries.

Timeliness in field operations is very crucial in many USA situations and therefore it is also common to perform multiple field operations in a single field pass behind a single tractor, for example tillage, fertilization, pesticide application, and planting in order to increase productivity and reduce labour costs.

In crop promotion and protection there is increasing use of variable rate application system in order to only apply the fertilizer or pesticides were it is needed. Automated GPS guidance and individual nozzle shut-off minimize skips and overlaps. Mechanical weed control has declined in the past years but there is now renewed interest due raising concern for environmental aspects and greater production of organic crops.

Yield mapping during harvest has been an area of recent development and has had uneven adoption by farmers including automatic quality property measurement and adaptive control of the harvesting machines.

The use of electronic and information technologies will expand, with a movement towards obtaining maximum quantity and quality from each plant with minimum economic investments and environmental impacts. Much of the improvement will be due to more and improved sensors, which will more accurately determine the characteristics of soils, crops, and pests, even in complicated physical, chemical, and biological agricultural production systems.

In the Session 2 – Part 2 the mechanization of less industrialized has been areas.

The Keynote Report "**Mechanization in Latin America"** by Ettore Gasparetto (University of Milan, Italy) and Luis Marquez (Universitad Politecnica de Madrid, Spain), provides a very deep overview of the Latin America countries, with particular attention to Argentina, Brazil and Mexico. After a general introduction concerning the different socio-economic data, as well as, the available resources and input for local agriculture (water, land, use of fertilizers), the report describes the various agricultural environments in Latin America, the fertility level of the soils and defines the land surface suitable for different food crops (cassava, cotton, corn, beans, paddy, sorghum, soya, sweet potato, wheat and potato). For each of the above mentioned countries, the authors considers the peculiar characteristics of the agricultural sectors (total and direct employees, main crops cultivated area and production) and the industrial sector related to mechanization supported by interesting structural index (i.e.: market volume, industrial turnover, imports and export flows, number of manufacturers and employment, machinery type and units in last years).

Finally, after a brief overview on the past contributions about the topic of the Latin America mechanization, the two Authors emphasize the development of the current research and the future prospects.

As regards the mechanization, Latin America presents significant differences among the regions, due to the agro-climatic and the high socio-economic variability; in some areas (in the south cone countries, particularly), a conservative agriculture by advanced mechanical technology – including Precision Agriculture systems - is carried out; on the contrary, in big areas of Central America, Caribbean and Andean Countries, the subsistence agriculture is performed. Mechanization of big or small farms, often results very difficult in specific conditions due to some environmental factors that make practically impossible the use of common machinery or require the utilization of specialized tractors and implements. For small farming it is necessary to consider the economic impact of the mechanization costs on the farmer's income; on the other side, the promotion of contractor enterprises - with the participation of the local farmers (that may realize this activity as a complement of their agricultural activity) - opens perspectives for a full development, including local repair and technical assistance shops.

The Keynote Report "**Agricultural mechanization in India"**, by Gajendra Singh (Doon University) and Surendra Singh (Agricultural Machinery Manufacturers Association, India), starts with an interesting general introduction on the main indicators of the Indian agriculture. Some fresh data – like: total cultivation area (141 Mha; 65% of which irrigated), contribution of agriculture on Indian GDP (14% with 50% of labor force), farm size (63% holdings less than 1 ha, accounting for 19% the operated area while over 86% holdings less than 2 ha, accounting for nearly 40% of the area), crops production (in 2013-14: 104 Mt of rice, 94 Mt of wheat, 35 Mbales of cotton and 358 Mt of sugarcane) - are absolutely impressive returning the idea of the "dimension" of the Indian agricultural sector.

Then the report takes in consideration the farm mechanization, providing many data on the evolution (from 1965 to 2015) of Indian overall mechanization level (currently fixed around 40-45%, but ranging from 34-45% in Eastern-Southern regions to 70-80% in Northern areas of India) and its intensity (specific installed power: currently 2,14 kW/ha and 1,00 kW/t; tractor density: 24 ha/unit). The different sources of power available on the Indian farms for doing various mobile and stationary operations are also investigated in the period 1960-2015, showing a constant decrease in animal power use compared to a constant increase of mechanical power.

Tractor population in India has grown from 0,037 million in 1960-61 to 5,946 million units in the year 2014-15; in the same period, consequently, farm power availability from tractor increased from 0,007 to 1,09 kW/ha at an overall growth rate of 10% during the last 55 years. Contribution of tractors and power tillers was only about 2.4% of the total farm power in 1960-61 which increased to 52% in 2014-15. Sale of tractors and power tillers has continuously increased during last 50 years and seems to be stabilizing in recent years.

Generally speaking, the total power availability on Indian farms has increased from 0,32 to 2.14 kW/ha during 1965-66 to 2014-15 and the overall mechanization level in India is only 40-45% even though 90% of the total farm power is contributed by mechanical and electrical power sources. One of the major constraints of increasing agricultural production and productivity is the inadequacy of farm power and machinery with the farmers. The average farm power availability needs to be increased to a minimum of 2.5 kW/ha by 2020 to assure timeliness and quality in field operations, to undertake heavy field operations like sub-soiling, chiseling, deep ploughing and summer ploughing. Finally, the report analyses the status of the market considering both tractors sales and farm tools and implements sales.

The last Keynote Report "**Agricultural mechanization in Africa: development and prospects"**, by B. Snobar (University of Amman, Jordan), B. Sims (Engineering for Development, UK), J. Kienzle and J. Mpagalile (FAO), shows the situation in African continent, generally characterized by a very poor socio-economic situation and by a low-level of input factors in agricultural production.

Mechanization in Africa is considered from the North Africa (NA) and Sub-Saharan Africa perspectives (SSA). Data are summarized to give an overall picture of the agricultural sectors, both in Africa as a whole and NA. Although the continent is potentially rich in agricultural land, severe soil degradation is seen as one of the root causes of stagnating and declining agricultural productivity.

The use of farm machinery is at a low level compared to other regions of the world, although NA agriculture is more mechanized than that in SSA: the number of tractors per 1000 hectares in SSA is 28 and the growth between 1961 and 2000 in SSA is 28% compared to 500% in Asia, 469% in Latin America and Caribbean and 1350% in the Near East and NA.

The need for an improved agricultural mechanization supply is discussed in detail; the main benefits of mechanization include: increased land and labour productivity, improved timeliness and reduced drudgery.

The importance of taking a holistic view and considering mechanization not just for primary production, but along the agricultural product value chain is also examined, as is the need for sustainability and the conservation of natural resources.

These activities are considered in turn and expanded to analyze their potential contribution in the African context. The way forward is discussed and it can be seen that sustainable crop intensification following FAO's guidelines will be key to increasing land and labour productivity, improving soil fertility and making cropping systems more climate-smart.

The public sector should not be involved in the supply of mechanization services but it has an important role to play in the development of sustainable mechanization strategies and the creation of an enabling environment to facilitate the private sector's provision of vital mechanization inputs. Capacity building is one such important public sector function.

The over-arching conclusion is that a holistic view needs to be taken of the provision of mechanization to African farmers. Emphasis should be on raising smallholder farm productivity and reducing the drudgery associated with the use of the hand-hoe.

In the Session 3 – **Convergences of science and technologies in agricultural engineering** new issues and opportunities offered by the most appropriate management of the relationship between science and technology for the development of agricultural engineering were discussed.

The subject was introduced by a vision Keynote Report "**Technology convergence and innovation**" by Fedro Zazueta (University of Florida, USA) based upon two basic principles: we gave much higher value through innovation than by marginal increases and efficiency; innovation opportunities occur when new science and new technology converge each other and so doing we can have the best return on value.

The most significant example is the development of IT that comes from the convergence of three technologies: electricity, telephone system and telecommunications, which led to the birth of the computer network. So the convergence of these technologies revolutionized our access to information that evolved into knowledge and when this happens, things change deeply.

In the past years agricultural engineering was mainly focused on mechanization, electrification etc. but now IT and biology became important part of the discipline creating big opportunity for innovation.

Therefore great emphasis must be given to education which constitutes the single most important factor to successfully face the rapid evolution of new technologies. "Teaching technologies" as well must evolve with strong focus on on-line learning and understanding psychology of learning and pedagogy in order to improve learning outcome and reduce the cost of instruction.

The new challenge will be the way in which all this new technologies can converge in the agro-food chain and the role of machines in the agro-food value chain of the XXI century.

Afterward four position papers have addressed specific aspects. The first position paper "**The Economic Perspective**" by Gerhard Schiefer (University of Bonn, Germany) underlines how economics can be a barrier or a driver to innovation. Technology and economics must converge in the different stages of the innovation process: discovery; marketable product; adoption by business. Without economic consideration the technology will not became innovation.

The second position paper "**Social and ethical considerations**" by Cesare Zanasi (University of Bologna, Italy) assert that agricultural mechanization in itself is neither good nor bad. It depends on two keywords: context and sustainability, which are strictly related to the social and ethical aspects. Good mechanization should enhance labour access and labour conditions, improve food nutrition and security, support small family farmers and integrated rural development, as well as should be related to sustainable supply systems.

The third position paper "**Machine-Human Relationship**" by Yoshisuke Kishida (Shin-Norinsha Co. Ltd, Japan) analyzes the evolution of agricultural mechanization considering as the new age will be the mechanization of human brain because in new machine more and more important will be the development of artificial intelligence (AI). According to the "Law of Accelerating Returns" by Ray Kurzweil the rate of change in evolutionary systems tends to increase exponentially and the

implications include the merger of biological non-biological intelligence. If Kurzweil's forecast is right we have to rethink the relationship between robots and the human beings.

The last position paper "**Production Development**" by Karl Renius (University of Monaco, Germany) stresses that the best investment to improve the economic and social level of any community is to get up the level of education. A second key issue is the ethical aspects, especially in African countries where corruption is a serious barrier to development. The creation of an African Institute of Technology, proposal already launched several years ago that has never been realized, might find new interest today under the pressure of refugee movements that involve heavily the economies of European countries.

During the Meeting the award ceremonies of the **"Giuseppe Pellizzi Prize"** and the **"UNASA-Club of Bologna Prize"** were held.

The "Giuseppe Pellizzi Prize 2016" – now in its 2nd edition - is an international prize dedicated to the best PhD Theses on farm machinery and mechanization. The three winners, selected by an evaluation committee composed of the Members of the Management Committee of the CoB and a member of board of the "Accademia dei Georgofili", are:

- 1st classified: Dr. Alireza Pourreza (USA), PhD Thesis: "*Citrus Huanglongbing disease identification using computer vision and machine learning*";
- 2nd classified: Dr. Marco Ramm (Germany), PhD Thesis: "*Systematic development and analysis of continuously variable transmissions with inner power split for mobile machinery*";
- 3rd classified: Suray Amatya (USA), PhD Thesis: "*Detection of cherry tree branches and localization of shaking positions for automated sweet cherry harvesting*".

The winners received the award from President of FederUnacoma, Massimo Goldoni, who warmly congratulated them.

The "UNASA-Club of Bologna" rewards the best scientific work published by a less than 38 years old Italian researcher in a referee international journal. The winner of this first edition, who was awarded and congratulated by the President UNASCA, Michele Stanca, was:

- Dr. Valentina Giovenzana (Italy), scientific article: "*Testing of a simplified LED based vis/NIR system for a rapid ripeness evaluation of white grape for Franciacorta wine*" published in the Elsevier journal *Talanta-The International Journal of Pure and Applied Analytical Chemistry* .

CONCLUSIONS and RECOMMENDATIONS

SESSION 2 – THE 25 YEARS OF CLUB OF BOLOGNA

The Participants consider that the volume provides a broad and comprehensive overview of agricultural mechanization in different areas of the world and unanimously:

- ✓ **recognize** that mechanization and technology needs vary considerably among different areas and it became increasingly important to evaluate agricultural mechanization impacts on value chain systems overall;
- ✓ **acknowledge** that the agricultural mechanization development of in industrialize regions has been amazing but increasing attention must be addressed to improve sustainability from the environmental and social point of view;

- ✓ **highlight** that manufacturers need to be prepared to understand that automation is increasing productivity of machines resulting in a decrease in the required volume of machines (lean asset);
- ✓ **ascertain** that mechanization has achieved a high level of success for major crops but is still a big challenge for specially crops such as fruit and vegetables to which much more attention should be paid ;
- ✓ **recognize** that Latin America and India have started a positive process of development of agricultural mechanization while Africa and especially the regions Sub-Sahara regions still have a long way to go;
- ✓ **recommend** highest priority of agricultural mechanization in Sub-Sahara regions with close cooperation between local and international organization and agricultural machinery stakeholders;
- ✓ **note** that the establishment of national networks for the promotion of technology and agricultural mechanization in Africa can make a significant contribution;
- ✓ **recall** that politic, economic, social and organizational issues are more important than technology to increase the agricultural productivity in developing countries and especially in Africa;

SESSION 3 – CONVERGENCES OF SCIENCE AND TECHNOLOGIES IN AGRICULTURAL ENGINEERING

The Participants, recognizing that agricultural engineering originally born to transform agricultural society to industrial society has now changed to a complex multi-disciplinary system in which crop system, sensors, data management, planning and decision making converge, unanimously:

- ✓ **believe** the harmonic fusion of science and technology is a challenging topic and plays a key role in the development of innovation in agricultural mechanization;
- ✓ **notice** that education as well as ethical and social concerns of technological adoption are the most important issues to enhance food security and sustainable social development;
- ✓ **underline** that education is the key investment to face the increasingly rapid progress of technology and innovation, and close attention should be focused on new teaching technologies in order to improve learning outcome;
- ✓ **emphasize** that economics can be a barrier or a drivers for innovation and only an appropriate combination of technology and economics enables effective development of the innovation process in the food chain;
- ✓ **stress** that Artificial Intelligence is developing very rapidly and intellectual and physical control function as human ability will be gradually replaced by AI operation; so the agricultural engineering must be ready to step from nowadays first unmanned machines to robots that can operate autonomously.