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Agricultural Education in the 21st Century: North American perspective

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I – Background

The topic of this conference, Agricultural Education in the 21st Century, is certainly very timely. As the conference title states, we are indeed facing a global food security challenge as the world population continues to grow over the next several decades. Furthermore, agriculture has a significant environmental footprint which must be reduced as part of a global effort for long-term environmental sustainability.

The focus of much of the discussion on agricultural education has been on declining enrolment in traditional agricultural programs. This is understandable when one considers the challenge that the world faces in providing nutritional security to a rapidly growing global population. However, structural changes in our food system over the past half century have had a major impact on the demand for agricultural graduates. Chief among these has been the mechanization of agriculture and the associated increase in scale that have dramatically changed agriculture in developed countries so that those employed directly in agriculture now number as little as one tenth of those employed 50 years ago.

There are additional forces at work that are also influencing the choice of programs offered in agricultural faculties. The first is a recognition that environmental sustainability is threatened due to the demands on our ecosystem imposed by the rapidly increasing human population and, thus, there has been a significant growth in opportunities for graduates who have the technical skills to deal with a wide array of environmental issues, including reducing the environmental footprint of agriculture. Agricultural faculties are well placed to offer programs in this area due to the broad disciplinary base of agricultural faculties in both the natural and social sciences in areas relevant to the environment.

The food-nutrition-health continuum and the recognition of the importance of nutrition to maintaining a healthy population has spurred another area of growth in undergraduate and graduate education. As health care costs have escalated as a result of the epidemic of chronic diseases (obesity, diabetes, heart disease and cancer), there is a growing realization that the solution is to reduce the incidence of these chronic diseases in the first place by placing more emphasis on programs to support heathy living. Clearly, nutrition has a central role to play in human health and indeed there has been substantial growth in demand for dietitians and related health professionals.

Finally, the bioeconomy is emerging as an area of interest as governments encourage renewable sources of energy, as well as green chemistry, as an alternative to the wide array of products produced from the petrochemical sector. At the University of Alberta we recently engaged industry and other stakeholders to provide guidance on a proposed new bio-industrial program in this area. Although the program has not been officially launched due to budget constraints, the pro-

posed program illustrates an emerging area of opportunity for graduates. The program also serves as an example of the evolution of agricultural faculties from the traditional BSc agriculture to include programs that encompass environmental and conservation sciences and those that link food, nutrition and health. This broadening of the traditional agricultural base has been in response to growing demand for graduates in these areas and it has helped boost enrolment in many North American agricultural faculties to record levels at a time when enrolment in traditional agriculture programs are static, or in decline.

As we focus on agricultural education in the 21st Century, we also need to be cognizant of the critical importance of soft skills for a successful career. A recent study[1] co-sponsored by the Association of Public and Land Grant Universities (APLU) is particularly enlightening in terms of the critical importance that employers place on these skills when recruiting employees. The results of this study merit particular attention at this conference as employers ranked soft skills higher than the technical skills that are the primary focus of curriculum development at universities. Clearly, soft skills are critical attributes in securing employment and for long-term career success in agriculture and life sciences.

Before discussing the University of Alberta bioindustrial program and the APLU study, I will provide some background that I hope will help promote discussion at this conference as we look to the future of agricultural education in the 21st Century. The key message is that undergraduate and graduate programs offered by agricultural faculties in North America have changed dramatically over the past half century. From a focus on production agriculture, programs have evolved to include the broad areas of environmental sciences, nutrition and health, and the bioeconomy as demand for graduates in these areas has often outstripped demand for traditional agriculture graduates. This trend is likely to continue in the future and thus we need to take a very broad view of agricultural education if we are to continue to be successful in attracting students who will go on to rewarding careers in helping solve some of the great global challenges confronting our planet.

II – Population explosion fueling global nutritional and environmental challenges

We are all aware of the explosion in the world population over the past 100 years. This dramatic growth is captured very nicely in the words of Dr Donald Shaver[2] when he states, *"Personally, I am astonished when I contemplate the simple fact that since I was born in 1920, the world's population has more than quadrupled and in less than four decades it will grow by half, to 9 billion"*. This dramatic increase in population is at the heart of the challenges that we face today in terms of food and nutritional security and environmental sustainability. To put things in perspective, consider that it took about one 100 thousand years from the origins of humans until 1825 for the world population to reach one billion people. A mere 100 hundred years later the world population had doubled to two billion, followed by an additional billion 33 years later bringing the population to three billion in 1960. Even more remarkable is that it only took between 12 and 15 years for each of the next four billion growth in world population – **thus four billion people were added to the world population between 1975 and 2011** when we reached a global population of 7 billion. In the face of this extraordinary growth in population, it is hardly surprising that we are

[1] Crawford, P., Lang, S., Fink, W., Dalton, R. & Fielitz, L. (2011). *Comparative Analysis of Soft Skills: What is Important for New Graduates?* Washington, DC: Association of Public and Land-grant Universities. Special thanks to Wendy Fink for permission to use the study results and for providing the PowerPoint presentation illustrating the study.

[2] The Gene Scene, Summer 2012.

being challenged as never before in terms of nutritional security and environmentally sustainability. Such massive growth has placed a huge burden on the planet that we call Earth which now faces the additional challenges and uncertainty associated with global warming.

III – Agriculture – the great success story of the 20th Century

Although we are naturally concerned that three quarters of a billion people go hungry every day, we often overlook the incredible success story that has allowed us to produce enough food to feed 7 billion people. When the world population reached 3 billion in 1960 most commentators did not believe that the world could produce enough food to feed 5 billion, let alone 7 billion. When you consider the amount of food wastage and the unequal distribution of the world's wealth, the problem is not that we do not produce enough food but rather that the food produced does not reach all the world's population. In the midst of the nutritional and environmental challenges that we face today, we should take pride in the great agricultural success story of the 20th century, namely the fact that we were able to ramp up agricultural output in such a dramatic fashion to feed a global population that increased from 3 billion in 1960 to 7 billion in 2011. Consider also that the food to feed the first 2 billion people came almost entirely from increasing the agricultural land area whereas most of the increased production over the past half century has come from increased productivity brought about by technology and increased fossil fuel inputs.

IV – The imperative to reduce the environmental footprint of agriculture

As we look to the future and the expected growth in population to 9 billion in the coming decades, there is another reality that we need to face, that in addition to producing more food, we need to do so with a much smaller environmental footprint. Reducing the environmental footprint of agriculture will indeed be a huge challenges in the decades ahead. This is especially true when you consider that growing affluence in developing countries comes with increased demand for animal protein and an associated higher environmental footprint. Consider also that the growth in world population will occur primarily in developing countries with China and India predicted to be home to fully one third of the world population. It is also projected that there will only be a handful of countries with the capacity to be major exporters of food. While exports will continue to make an important contribution to nutritional security, the reality is that the key to global food security is "local" food production in countries with high population density.

V – Agriculture as a solution provider

As discussed above, estimates on numbers of people who suffer from food insecurity only tell part of the story. As food security is generally synonymous with caloric self-sufficiency it does not account for those who suffer from some form of nutrient deficiency, estimated to be as much as one billion people. Paradoxically, we are also faced with a rapidly growing population – as many as one billion or more, who suffer from obesity and chronic diseases such as diabetes and heart disease that are threatening the sustainability of health care systems. The traditional approach of spending over 90% of health care dollars on treatment of disease is not sustainable. Clearly, the answer is to take measures to deal with the root causes of the chronic, and largely preventable, diseases that are consuming so much of our health care dollars. Nutrition is a key determinant of health and there are indications that governments are prepared to invest more in this area as one of the foundations of maintaining a healthy population. Many agriculture faculties have grasped this opportunity by expanding nutrition programs that offer graduates interesting and challenging

careers as dietitians. These programs are very attractive to students as shown by the rapid growth in enrolment in nutrition programs. The expansion of agriculture to include the link to nutrition and health provides an opportunity to move the focus of agriculture from "food" security to "nutritional" security. The former is most frequently seen as relating to caloric self-sufficiency while the latter embodies the critical importance of nutritional status in the maintenance of health.

VI – Impact of technology and scale of farms on agricultural education programs

As we look to the future and consider the question of agricultural education needs in the 21st century, we also need to recognize that one size will not fit all as agriculture has evolved very differently in developed countries compared to developing countries. As stated in FAO's 2014 State of Agriculture[3], "The sheer diversity of family farms and the complexity of their livelihoods mean that one-size-fits-all recommendations are not appropriate"… "Each country and each region needs to find the solutions that best respond to family farmers' specific needs and the local context".

In 1930 32% of the Canadian population lived on farms. Today 2% of the Canadian population are directly involved in agriculture. Even more striking is the fact that in the US and Canada, 4% of farms produce 66% and 50%, respectively of the total farm gate value. Contrast this with India where over half the population is involved in agriculture. Clearly, these huge differences in scale will impact the demand for, and the skill sets required of, graduates in the 21st century. Paradoxically, FAO states that 500 million farms produce 80% of the world's food and it is indeed disturbing that a large proportion of those suffering from food and nutritional security are small farmers and agricultural workers.

VII – Evolution of agricultural education programs

As farms in North America have evolved to larger and more mechanized operations with fewer employment opportunities in agricultural production, higher education institutions have also evolved in tandem. One hundred years ago the focus of agricultural universities/faculties was on production agriculture and the degrees offered were primarily agriculture degrees. Over time this has evolved so that, today, most faculties have changed their name to include words like "environment", "natural resources" and "life" as part of the faculty name. Similarly, degree programs have evolved so that students pursuing agriculture degrees often constitute a relatively small proportion of total undergraduate and graduate enrolment.

Although each institution will differ somewhat in the actual programs being offered, there are some broad patterns that can be observed. The first is an expansion of the production agriculture base to include increased emphasis on food science and technology driven by an increased awareness of the importance of value-added and the associated career opportunities in areas such as food technology and food safety. At the same time that is a greater public awareness and student interest in the area of nutrition as it offers a growing number of attractive employment opportunities.

The third area of growth has been in the environmental area. Agricultural scientists are well placed from a discipline perspective to play a leading role in the broad area of environmental sustainability. This has been a key area of growth in terms of students and research and thus has played an important role in helping agricultural faculties maintain and grow student numbers in the face of declining interest in traditional agricultural sciences. For example, at the University of

[3] The State of Food and Agriculture. Food and Agriculture Organization of the United Nations, Rome 2014.

Alberta there has been a dramatic shift in programs offered over the first 100 years in the life of the faculty, with the major changes occurring over the past 25 years. Over the first 70 years of the faculty students were primary enrolled in the BSc Agriculture program. Today about one third of our students are enrolled in nutrition and the next most popular program is environmental and conservation sciences with agriculture a distant third.

The recent introduction of a new animal health program has also proven attractive to students who are interested in both production and companion animal health. Overall student numbers are at an all-time high even though entrance requirements have increased substantially over the past decade. Students in all fields secure well paid jobs on graduation, the vast majority in their disciplinary area of interest. Demand is particularly strong in the agronomy area and employers are having difficulty finding suitably qualified individuals due to declining enrolment in this area.

As we look to the educational needs of the 21st century we need to be sure that we are asking the right questions regarding demand for agricultural graduates in the 21st century. If there is a lesson to be learned from the 20th century, it is that there were massive changes in agricultural production systems. We should expect these changes to continue in the 21st century and with them there will be impacts on the educational programs needed to meet the changing career opportunities in this sector.

VIII – Case Study: Stakeholder engagement in the development of a new Bio industrial program

The Province of Alberta, Canada has a long history of conventional oil and gas development and it has also experienced major growth associated with oilsands development over the past couple of decades. Alberta has a large land mass that supports strong agriculture and forestry sectors that are well placed to provide renewable feedstock to support a growing bioeconomy industry. The Province also has a well-educated workforce and high quality universities and colleges that, together with the Provinces abundant natural resources, provide a strong foundation for the further diversification of the economy in the renewable area. The Alberta Biorefining Conversions Network (BCN) brought together 85 senior leaders from industry, government and academia "to discuss the current global bioindustry landscape, the projected bioeconomy workforce and existing bioindustrial education programs; and develop a path forward for program development and workforce creation in Alberta"[4]. The stakeholders at this workshop were asked to review current educational programs at universities and colleges, to identify gaps and make recommendations for future programming.

1. The Banff Workshop participants were asked to address the following questions

- What are the core competencies and skills that industry is looking for in High Quality Professionals (HQP) and skilled labor for the emerging bioeconomy?
- Current and forecasted local demand for a bioeconomy workforce?
- The bioindustrial landscape, in regards to workforce in other jurisdictions; and thus what is it projected to look like in Alberta.
- What institutions have programs dedicated to training HQP in the bioindustrial space? Have they been successful?

[4] Building Alberta's Bio-Industrial Talent Pool. Proceedings from the Alberta Bioconversions Network (BCN) Workshops, Banff. March 2012 and October 2014.

- What are the short and long term forecasts for both education and industry requirements?
- What can we learn from existing examples of programming in this space?
- What are the steps and timelines around implementing new programming? Do these align with industry?
- Is there any alignment between bioindustrial skills required by industry and the current system?
- What are the best paths forward?

2. Bioindustry skills and competencies identified

When considering the key jobs in this sector developing towards 2020 the workshop identified many different types of skills, however it was decided to focus on the following High Quality Professionals (HQP's):

– Primary producers: agriculture, forestry & biomass farmers/crop managers

– Trades: electricians, plumbers, machinery, other

– Technologists (primarily) and technicians

– Research scientists

– Engineers

3. The skill sets identified for Technologists, Scientists and Engineers were as follows

Technologists:

– More multi-disciplinary technologies & instrumentation

– Some added economics/business, project management competency

– Support system for small and mid-sized enterprises (SME's)

– More responsibility for problem-solving so as to handle 'routine' challenges (whereas difficulties or exceptions to routine go to engineers to handle)

– Work in/lead cross-functional teams

– Potentially move in from other sectors and need "re-set"

– Rapid re-training & re-tooling mechanisms

Engineers:

– Need to understand more bio-processes, build this into 4-year B.Sc. programs

– Raw materials coming in, biomass handling & transport

– Plant-wide process knowledge: know petro/chemical AND bio-systems

– Adaptability, added knowledge in business, communications, economics

– Multi-disciplinary in thinking and experience/assignments

Scientists:

– "Green" chemistry, lifecycle analysis, water efficiency

– Reduced environmental impact

– High-value end of biomass opportunities

– Wide variety in Bioindustry – fermenting, virology, biotech

– Conventional Focus, expanded/applied to new areas, natural health products

– Again, multi-disciplinary, theoretical + practical application

– Post-grad - more 'fluid' specializations

4. Potential undergraduate degree programs

Hon BSc. Bio Resource Program – Integrated Business-Science Program

Hon BSc. Bio Industry Technology

Hon BSc. Food Science – Adapted towards BioIndustry

5. Example of generalist undergraduate Bio-Resources Degree overview

Core Program 1st & 2nd Year Basic Elements	**Minors/Majors** 3rd & 4th Year Specialization/Focus
• Statistics	• Synthetic biology
• Microbiology	• Fermentation
• Molecular biology	• Industrial microbiology
• Genetics	• Life cycle analysis
• Organic chemistry – extraction/purification	• Advanced materials science/handling
• Chemical/biochemical conversions	• Capstone: systems thinking type
• Genetically modified organisms	• Processing/transformation of biomass
• Entomology	• Biofuels
Options/Electives	
• Macro/micro Economics	• Non- Thesis M.Sc. – BioProcess Engineering?
• Business/marketing	
• Strategic communications	
• International trade & regulatory environ	
• Ethics	

6. Program design conclusions for generalist undergraduate degree

– This kind of program IS possible – and there is a strong desire to advance

– It might be an adaptation of an existing degree – i.e. a new "major"

– Could be a new cross-faculty "program"

– Clarify target audience, then build the "business case"

– Involve leaders from industry and government and other external partners

– Bring together resources from various faculties – joint programing, perhaps across 3 universities.

– Work on the program is currently on hold as the introduction of a new program could not be justified at a time of reduced government support for existing programs.

XI – Soft Skills: Results APLU survey of employers, alumni, faculty and graduates

Michigan State University conducted a cross-institutional survey, in collaboration with the Association of Public and Land Grant Universities (APLU) and the University Industry Consortium (UIC), to determine the views of employers, faculty, alumni and students regarding the role of soft skills for a successful transition to careers in agriculture, natural resources and related careers. The study asked the question, what soft skills are employers looking for in new graduates? The survey involved over 8,000 people across the US that included employers, faculty, alumni and students. An initial study was conducted to identify and cluster the soft skills into seven broad groups, namely, Experiences, Team Skills, Communication skills, Decision Making/Problem Solving Skills, Self-Management Skills and Professional Skills. Employers and Alumni were drawn from a broad cross section of economic sectors that included For Profit, Government, Non-profit/non-government, and Higher Education.

One of the key findings from the study was that employers and alumni ranked soft skills as number 1 whereas students and faculty ranked soft skills as number 2 and 3, respectively (see Fig. 1). Faculty and students ranked discipline knowledge as number 1 compared to rankings of 2 and 3 by alumni and employers, respectively. When it came to the relative importance of each of the seven soft skills all groups ranked communication as number 1 and decision making/problem solving skills as number 2. Over half the respondents believed that soft skills training should be a shared responsibility between universities and employers. Students ranked Experiences much higher (#3) than employers (#6) in terms of importance for successful entry to the work place.

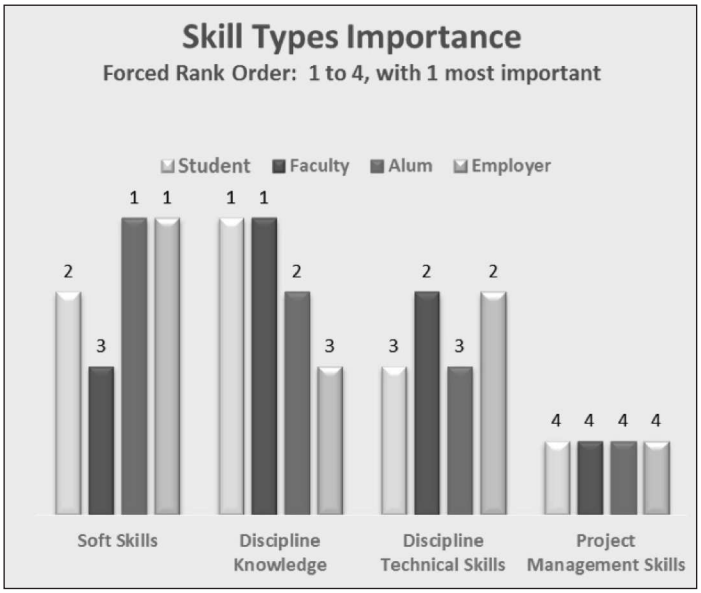

Fig. 1. Importance ranking of types of skills from students, faculty, alumni and employers.

The survey revealed some very clear differences among employers, faculty and students regarding the overall importance of soft skills, relative to disciplinary skills, as well as in their ranking of the relative importance of the soft skills. An important question for universities is how should these results inform curriculum development for the 21st Century?