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LIVESTOCK REPRODUCTIVE BIOTECHNOLOGIES: ROLE IN LAND PRESERVATION AND GREEN AGRICULTURE

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ABSTRACT

Green agriculture is a product of development, of adopting innovations from the results of scientific research activities and careful planning. It is associated with building a concept of ecological civilization, of making an overall plan for urban, including rural socio-economic development, and establishment of new ecological socialist countryside. It is a manifestation of increased productivity, promotion of the reasonable distribution of rural productivity, optimization of the allocation of factors and maximization of economic benefits. With the increasing human population, urbanization and expansion of land utilization, integrated crop-livestock husbandry is important to promote green agriculture as livestock provide manure aside from catering to the increasing requirements for milk and meat for human consumption. As land scarcity increases, poorer land is used, causing the marginal productivity of labour and of land to decline. So high priority should be given to maintaining soil productivity by increasing agricultural production through yield increases with little or no additional land. Livestock genetic improvement is therefore needed to produce the animals with superior genetics that could produce the needed milk and meat without necessarily raising the high number of livestock and occupying much space to meet the human requirement. In the implementation of livestock genetic improvement programs, reproductive biotechnologies play an important role to maximize and facilitate the multiplication of genetically superior bulls through artificial insemination, while ovum pick up and *in vitro* embryo production and transfer maximize the female contribution to genetic progress. The theories and practices on the role of reproductive biotechnologies on green agriculture is presented.

Key words: livestock production, land preservation

INTRODUCTION

Green agriculture is an agricultural system that everybody must work on in order to protect the environment and sustain the good health and well-being not only to the human population but of the earth as a whole. It is a product of development, of adopting innovations from the results of scientific research activities and careful planning associated with building a concept of ecological civilization, of making an overall plan for urban including rural socio-economic development, and establishment of new ecological socialist countryside (ILCA 1992).

To promote green agriculture, increase in agricultural productivity must be manifested and this has to be promoted and distributed in all farming communities. Economic benefits need to be maximized and this can be attained by systematic research and careful results analysis in order to develop policies and guidelines coupled with proper implementation and monitoring. With the increasing human population, urbanization and expansion of land utilization, increase in productivity while protecting the environment is inevitable.

In the attainment of green agriculture, an integrated crop-livestock husbandry is important as livestock provide manure for organic fertilizer, utilizes farm residues and converts grass and forage into milk and meat. As catering to the demand of food for human population increases, increase farm operations is needed and naturally, land scarcity increase, resulting in use of poorer land causing the marginal productivity of labour and of land to decline. So high priority should be given to maintaining soil productivity by increasing agricultural production through yield increases with little or no additional land. Agricultural technologies are therefore needed and in the field of livestock production, a livestock genetic improvement program is necessary to produce the genetically superior animals for milk and meat without necessarily raising high number of animals and occupy much space. Raising of genetically superior animals also leads to utilization and conversion of crop residues into usable manure as organic fertilizer.

MISCONCEPTIONS ON LIVESTOCK ROLE IN GREEN AGRICULTURE AND ENVIRONMENT

For many years, a growing volume of criticism against livestock exists, specifically that livestock biotechnologies may be in conflict with the basic principles of green agriculture. Prominent among these criticisms are that livestock contributes to: increased desertification through long term over grazing particularly of semiarid rangelands; deforestation by lopping branches for use as fodder and felling trees to make way for pastures; the greenhouse effect, since livestock produce methane as an end product of rumen digestion; and water and environmental pollution through animal wastes.

In a global context, these issues were clarified by ILRI in a FAO publication published for global information (http://www.fao.org/Wairdocs/ILRI/x5462E/x5462e04.htm#livestock production, resource management and environmental degradation). In was indicated that the above criticisms on livestock are without hard evidence and many hard evidence is emerging to show that livestock are not the environmental villains. An extensive literature review on the impact of livestock on rangelands (Dodd 1991) concluded that the effects of grazing and drought have been confused and that there was no solid evidence of irreversible effects on vegetation from livestock. Long term research in the Sahel in Mali clearly shows the resilience of Sahel rangelands and that annual biomass yields closely track annual rainfall even after extended drought and heavy grazing pressure (ILCA 1992).

Deforestation and expansion of ranching into forests was also issued but research showed that neither the market nor profits as such are the main reason for expansion of ranching (Belk et al. 1992). It is rather the policies of various governments that encouraged land speculation (Hecht 1989, Durning and Brough 1991, Durning and Brough 1992, Kaimowitz 1994, McIntire et al. 1992). In fact, it was indicated that expansion of shifting cultivation due to poverty and population growth is a principal cause of tropical deforestation in developing countries (Cleaver and Schreiber 1992, Winrock 1992). On the other hand, livestock's contribution to the greenhouse effect has been overemphasized because ruminant livestock contribute only about 2.5 per cent of the total greenhouse gases. Gas emissions from cars and industries are far greater and have been increasing at a much higher rate. The problem of pollution created through waste disposal is specific to intensive production systems in developed countries but this is being controlled by the adoption and implementation of biotechnologies such as conversion of the waste into energy source (McIntire et al. 1992).

In general, improved livestock productivity, economic development and sustainable natural resource management and green agriculture are not incompatible goals. Appropriate technologies, policies and institutions will, however, be required to achieve that goal. So, the aspects in livestock production that are supportive of green agriculture like the aspect of reproduction should be magnified in order to promote awareness and opportunities to utilize it. In this talk, the theory on the interplay of crops and livestock integration in order to attain green agriculture will be presented and discussed.

Data supporting the benefits achieved out of raising genetically superior animals, efficient land utilization and preservation, and support the achievement of green agriculture will be presented. At the end of the talk, the role of livestock on the attainment of green agriculture will be understood.

LIVESTOCK REPRODUCTIVE BIOTECHNOLOGIES

In the implementation of livestock genetic improvement programs, reproductive biotechnologies play an important role by maximizing and facilitating the multiplication of genetically superior bulls through artificial insemination while ovum pick up and *in vitro* embryo production and embryo transfer maximizes the female contribution to genetic progress. Below are the various reproductive biotechnologies deemed necessary and applicable in the promotion of green agriculture.

A. Artificial Insemination (AI)

Artificial insemination is the oldest reproductive biotechnology that is highly adopted to maximize the reproduction potential of males. In the promotion of green agriculture, genetically superior bulls that are highly fertile, using the advance semen quality analysis, and possess the high production potential for milk and meat based on progeny testing and other advance genomic markers, will serve as donors of semen. These male qualities are important in order to produce the milk and meat requirement without necessarily maintaining huge number of animals for breeding purposes. Hence, bulls that are to be maintained as donors of semen for artificial insemination must be those that are identified as genetically superior in terms of milk and meat with high fertility as determined and predicted by advance semen analysis such as Fourier Harmonic Analysis and *in vitro* fertilization assay (Duran and Hufana-Duran 2017), among others. Using the semen of these genetically superior bulls would mean production of calves that possess the bull genetic characteristics.

The AI techniques requires careful consideration of the following procedures; a) bull selection and screening, b) semen collection and quality analysis, c) semen processing and preservation techniques, d) semen thawing and handling, and e) female preparation and insemination.

Bull Selection and Screening. As earlier emphasized, bulls must be subjected to careful genetic analysis in a way that the production and fertility potentials are known. At present, genetic marker analysis and progeny test are used to predict the genetic potential of the males. To predict the fertility of a bull, *in vitro* fertilization assay, hypo-osmotic swelling test (Hufana-Duran et al. 2015) and Fourier Harmonic Analysis (Duran and Hufana-Duran 2017) can be used. Fertility analysis can be done once and when determined, the bulls can be used as donors and follow up test will depend on health issues of the animals, which are now conveniently tested by the advances in molecular biotechnology procedures.

Semen Collection and Quality Analysis. The techniques of semen collection and analysis is already an established procedure carried out and implemented by bull farms and semen processing centers. These procedures are carried out at least twice a week for each bull.

Semen Processing and Preservation Techniques. These laboratory procedures are carried out by technicians trained to perform the work. Techniques of processing and preservation is well-established and being practiced in large ruminants like cattle and buffaloes, with minimal application in goats and sheep (Leboeuf et al. 2000, Jimenez-Rabadan et al. 2016), but still under study in swine and in poultry (Lopez Rodriquez et al. 2012, Zaniboni et al. 2014).

Semen Thawing and Handling. These procedures are critical during the insemination process as the quality of the semen can be compromised if proper thawing and handling practices are not adopted (Hufana-Duran et al. 2017) and these can affect the overall success of the artificial insemination. The

AI technician or a staff assisting the AI technician plays the important role in ensuring that the standard operating procedure is met in carrying out this procedure. Failure to follow the standards would compromise the attainment of green agriculture as reproduction failure is the major consequence (Hufana-Duran and Duran 2015).

Female Preparation and Insemination. In the preparation of female for artificial insemination, the timing of estrus is very important. While natural estrus guarantees high success rate of AI if all other considerations were meet, variability on the timing of estrus occurrence among animals is a limiting factor especially in greatly dispersed areas. Estrus synchronization is another reproductive biotechnology that can be used in order to program the occurrence of estrus among females and perform AI in several females at one pre-determined time. This technology would enhance breeding the females and overcome long calving intervals that affect the production efficiency. Care, however, is needed in the implementation of estrus synchronization and AI and this is being done by trained and skilled technicians.

B. Embryo Transfer

Embryo transfer is the advance reproductive biotechnology considered as the most effective tool that guarantees the production of genetically superior animals (Hufana-Duran et al. 2004, Hufana-Duran et al. 2007, Hufana-Duran et al. 2008b). It involves the production or collection of embryos from proven genetically superior animals and transferring it to surrogate mothers (inferior genetic females can be used) for full-term development and propagation. This breeding scheme can facilitate the production and propagation of animals with superior genetics. However, it requires highly skilled personnel with laboratory and preferably with mobile laboratory facilities. Highly trained private and government practitioners can carry out the technology but it has to be executed by a team equipped with complete facility.

To carry out embryo transfer, genetically superior embryos are needed. Embryos can be produced in vitro or can be collected in vivo (Hufana-Duran et al. 2005, Hufana-Duran et al. 2008a).

In Vitro Embryo Production. In the in vitro embryo production, oocytes can be collected by Ovum Pick Up or OPU techniques from genetically superior female or can be sourced out from the ovaries of genetically superior females distained for slaughter in abattoirs (Hufana-Duran et al. 2009). Oocytes from these procedures are matured in vitro and fertilized using frozen-thawed semen from genetically superior bulls and the resultant zygotes are further cultured in vitro to produce the genetically superior embryos that can be used for embryo transfer.

Ovum Pick Up is an advance reproductive biotechnology that guarantees the female contribution on the genetic progress of the resultant calves. It involves the use of ultrasound-guided follicle aspiration using a vaginal probe that guides the technician to point the collecting needle to the ovarian follicle where the oocyte is to be collected. By this technique, genetically superior females that are producing milk can be used as donors of eggs without affecting their milk production performance. They can donate eggs twice a week for two-months or more resting them for two months prior to initiation of AI through normal estrus for their next calving. In this way, these genetically superior females can reproduce more calves than their normal capacity. This also mean that the production and multiplication scheme for high genetics animals is facilitated and enhanced.

For the oocytes retrieved from ovaries collected from abattoir, sources of ovaries have to be carefully selected to ensure that the female genetics is high. In this approach, genetically superior females that undergone health-related problems and are brought for slaughter are the main sources of ovaries. Females without concrete production record are not considered as sources. However, for meat purposes, females, even without concrete production records, are being screened by their size and quality of meat. Females that meet the standards of selection can qualify as sources of ovaries.

In in vitro embryo production, various technologies are available to cater any problems and cases that affects the reproduction of genetically superior animals. These technologies include; a) intra-cytoplasmic sperm injection or ICSI, b) sperm separation by density gradient techniques (Hufana-Duran et al. 2005), c) cloning by somatic cell nuclear transfer, d) sperm sexing, e) embryo sexing, and f) embryo splitting.

Intracytoplasmic sperm injection or ICSI is a technology use if the genetically superior bull has some problem on the motility of its sperm cells. While high fertile genetically superior bulls are required for green agriculture, there are cases in which genetically superior bulls has sperm motility and fertility problems but they are not culled due to genetic considerations. These bulls can still be maintained for reproduction using the techniques of ICSI. In ICSI, sperm cells of these bulls are injected into the cytoplasm of the oocytes in order to effect fertilization and subsequent production of embryo. It is an assisted in vitro fertilization performed by skilled technicians using a micromanipulator.

The sperm separation by density gradient sperm separation technique is use when the bull semen has low post-thaw motilities (Hufana-Duran et al. 2005). This involves the use of discontinuous layers (2 to 3 layers) of solution with higher concentration at the bottom and lowest concentration at the top where the semen is layered. This is then centrifuged to allow the motile sperm cells be separated from the dead populations and other contaminants. This way, only the motile sperm cells are used for in vitro fertilization allowing the genetically superior bulls with low post-thaw motilities still produce an embryo for embryo transfer.

The cloning by somatic cell nuclear transfer or SCNT is a technology used to reproduce a complete copy of a genetically superior animal. This involves collection of somatic cells from a superior animal and a recipient cytoplast which is an in vitro matured oocytes collected from ovaries of females from abattoirs. Recipient cytoplast is oocyte from any female buffaloes in abattoir. The nucleus of the in vitro matured oocyte is removed and the nucleus of the somatic cell from genetically superior animals is injected into the enucleated oocyte. The recipient cytoplast then receives the signal of fertilization that development of embryo commenced. This way, the genetics of the resultant embryo carries the whole genome of the genetically superior animal that was cloned (Hufana-Duran and Duran 2015). In this technique, if the cloned animal is a male then the resultant clone calf is also a male. This technology has the highest potential to propagate the best animals and promote livestock production capitalizing only with genetically superior animals thereby supporting the implementation of green agriculture.

Sperm sexing is another technology that allows the separation of the X and Y sperm cells, capitalizing on the difference of their DNA, so as to enable the production of embryos with pre-determined sex and when used for embryo transfer would also guarantee the production of calves with pre-determined sex. This technology is very important in the areas when the livestock raiser wishes to operate a dairy or meat enterprise.

Embryo sexing is another reproductive biotechnology procedure that enhances the production of offspring with pre-determined sex. It involves the use of micromanipulator to retrieve a fluid from the blastocoel of a pre-implantation stage embryo or a single blastomere of an embryo for analysis. Karyotyping or PCR techniques are used to determine the sex of the embryo (Hufana-Duran and Duran 2015). Like all other techniques on sexing, this technology offers positive impact on green agriculture as it promotes the operation of a dairy herd of genetically superior animals.

Embryo splitting on the other hand, is a reproductive biotechnology that involves manual cutting of the embryos, preferably before the cell-differentiation stage i.e. on or before the morula

stage. This technology is just to increase the number of embryos produced from a known genetically superior animal. However, the embryo sexing and splitting are technologies that are highly invasive and only highly skilled personnel can do the job. A private company with mobile laboratory and equipped with skilled manpower resources and facilities that can serve all the animal herds in the area is a potential strategy to implement this reproductive biotechnology.

In Vivo Collection of Embryos. For i*n vivo* collected embryos, the donors are usually treated with hormones through Super or Multiple Ovulation, often called SOET or MOET, and collecting the embryos for embryo transfer. This reproductive biotechnology has superovulated donor females that are guaranteed of superior genetics and also inseminated with bull of superior genetics. Embryos are collected on day-6 or 7 after artificial insemination or mating by a genetically superior bull. Pre-implantation stage embryos are transferred to surrogate mothers.

Cryopreservation. Cryopreservation is a technology used to preserve the embryos in liquid nitrogen whether it is produced i*n vitro* or collected *in vivo*. This technology allows long-term storage and transport of the embryos for embryo transfer without necessarily depleting the viability (Hufana-Duran et al. 2004, Hufana-Duran et al. 2007, Hufana-Duran et al. 2008). Slow-freezing method or vitrification procedure are both efficient in the preservation of the viability of the embryos. By the cryopreservation technology, the genetics of the genetically superior animals can be preserved and still be utilized for reproduction and propagation even after their productive life. Genetics of superior animals for meat can be preserved and can be reactivated for future reproduction and propagation. This minimizes space, management expenses, and labor requirements.

Theories and Practices

Reproductive biotechnologies such as those mentioned above can increase and facilitate the production and propagation of genetically superior animals. By maintaining these kind of animals, increase in milk production would mean increase in profit among livestock raisers (Acoba et al. 1992). Each livestock raisers have their own capacity to handle and maintain a number of animals in their herd. By maintaining the animals with superior genetics in the herd, there is no need to maintain huge number of animals to produce the needed milk to generate income, this would also mean less area needed to raise the animals thus, land preservation. While genetically superior animals may require more food and water, the conversion of these animals of renewable agricultural products and the waste that results from it is another potential benefit. Huge pasture areas can be efficiently utilized and agricultural waste can be recycled as feed that will be converted into milk and meat. Employment generation is expected to rise and coupled with proper operation, a green agriculture is highly promoted and preserved.

In most of the livestock operations in Asia, small scale farm management is dominant. This kind of system requires more space and manpower compared to what the western countries are implementing. The small-scale farm operations are mainly due to subsistence consideration and not on profitable operation. This could be attributed by the poor production performance of the animals that the farmers raise resulting to lack of interest to go further and increase the number of the herd. In the areas where animals are of good genetics, most of the farmers are inspired to raise more animals as the profit obtained from these animals is their driving force to keep more animals in the herd. Here, the use of the advance reproductive biotechnologies in order to improve the breed of the herd and produce high genetic animals is inevitable.

CONCLUSION

Reproductive biotechnologies play an important role in the attainment and promotion of a green agriculture as well as land preservation. Improving the efficiency rate of the various

reproductive biotechnologies is continuously undertaken in order to decrease the cost of implementation and improve the success rate.

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