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Breeding policy strategies for genetic improvement of cattle and buffaloes in India

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Abstract

Dairy cattle and buffalo production has undergone a major transformation resulting into a substantial increase in milk production thus helping our country to achieve top position in milk production in the world. Even though various animal breeding and management programmes have contributed to this improvement, there are constraints hampering the growth which require proper attention by initiating realistic breeding policies for genetic improvement of cattle and buffaloes. In view of this, optimum breeding policies for various classes of cattle and buffaloes are presented with their strengths and shortcomings. Technologies for selection of superior genotypes and multiplication of their germplasm are also being discussed. Finally, some breeding policy strategies for proper implementation of these programmes are recommended for adoption.

Keywords: breeding policy, cross breeding, grading up, selective breeding

Introduction

Livestock sector plays a critical role in the welfare of India's rural population. It contributes 9% of GDP and employs 8% of the labour force. This sector has emerged as an important growth leverage of Indian economy [1]. Among livestock, dairying has largely been considered as subsidiary to agriculture, however, during the last three decades, dairy cattle and buffalo production had undergone a major transformation thus resulting into a substantial increase in milk production and dairying has become a viable tool to diversify the agricultural production [2]. Our country has already raised to top position in milk production in the world which could be attributed to increase in the population of high yielding crossbred cattle and buffaloes coupled with launching of various breed improvement programmes by the government as well as different research and development organizations [3].

Various animal breeding and reproductive technologies for selection and faster multiplication of genetically superior cattle and buffalo germplasm, adoption of improved animal husbandry practices, expansion of infrastructure development on network of Artificial Insemination, animal health care, milk procurement and marketing facilities etc., have contributed significantly to increase in milk production. However, there are large number of constraints hampering these programmes and therefore, there is a need to mitigate the gaps and further optimize the use of resources and undertake pragmatic breeding policy strategies for genetic improvement of cattle and buffaloes [4].

Genetic diversity and breeding policies

India has rich and diverse genetic resources with 37 well defined breeds of cattle and 13 breeds of buffaloes. Although, we possess a large number of well defined cattle and buffalo breeds, they constitute hardly 20-25% of total cattle and buffalo population of the country [5]. The cattle and buffalo genetic resources with vast population of 187.4 million and 96.6 millions comprising large population of crossbred cattle and non-descript cattle and buffaloes are widely distributed in diverse agro-ecological regions of the country [6]. These diverse population groups reared in small herd size of 2-3 animals mainly by small, marginal and landless farmers of different socio-economic levels under different ecologies have suffered in the past without a uniform national cattle and buffalo breeding policy. However, the Government of India, on the basis of recommendations of National Commission on Agriculture and subsequent expert panels, has laid down broad guidelines of breeding policy for bovines as shown in Table -1 [3].

It is imperative that the country should develop strategic planning so that available resources in different agro-ecological zones of the country be exploited judiciously and utilize sustainably for further enhancing the productivity of cattle and buffaloes. Therefore, agro-climatic region and animal production system based breeding policy strategies with a focus on large scale implementation of improved animal genetics and breeding innovations by development organizations with active participation of farmers/breeders are discussed here under [7].

Before developing sustainable breeding strategies for improving the productivity performance of a particular breed/genetic group of animal population in

Table-1. Breeding strategies for bovines as recommended by Government of India [3]

Sr. No.	Type of animal	Breeding strategy	Purpose
1	Indigenous dairy breeds of cattle and buffaloes	Selective breeding	Milk production
2	Indigenous draught breeds of cattle and buffaloes	Selective breeding	Draught power
3	Indigenous dual purpose breeds of cattle	Selective breeding	Milk production and draught power
4	Non-descript cattle	Grading up with improved indigenous cattle breeds	Milk production /draught power
		Crossbreeding with exotic dairy breeds followed by selective breeding	Milk production
5	Non-descript buffaloes	Grading up	Milk production / draught power

a given agro-climatic region, it is necessary to have a comprehensive details of population size of breed along with analysis of existing activities such as farmer/breeder's perceptions and socio-economic levels, agriculture and livestock production systems, available feed and fodder resources, animal genetic resources, their production potentials and utilization pattern, breeding organizations, infrastructure and development facilities [8]. The Quinquennial All India Livestock Census contains information on the herd/flock structure, sex, age, etc. and it does not reflect the factual situation about the status of breeds in terms of their population. Hence, the actual population of each breed and their geographical distribution is not clearly known. The correct picture about these breeds would be available only when breed-wise census of the livestock is carried out and status and performance of breeds are surveyed in their natural habitat and the same has been initiated in the recent survey [9].

In the back ground of the collected and collated information on all above aspects, following region specific animal breeding strategies can be planned for conservation and genetic improvement of bovine genetic resources under different animal production systems.

Genetic improvement of non-descript zebu cattle by crossbreeding

The most rapid and effective approach to genetically improve the largest chunk of non-descript zebu cattle population is through crossbreeding with exotic dairy cattle breeds particularly in milk shed areas around peri-urban and industrial towns where good marketing facilities for milk and milk products and round the year availability of adequate amount of green fodder and quality feed resources exist. Past experiences of crossbreeding with exotic dairy cattle breeds like Holstein, Brown Swiss and Jersey proved to be an effective tool of bringing rapid genetic improvement for enhancing multifold productivity of non-descript cattle. Holstein Friesian cattle have been recommended as the breed of choice in the irrigated plains and Jersey cattle as breed of choice in hilly terrain and coastal areas for crossbreeding. The optimum level of exotic inheritance in crossbred cattle should range between 50 and 75% [10].

As a result of various research and development programmes on crossbreeding in dairy cattle particularly crossing non-descript cattle with high yielding exotic cattle breeds over the years, being the quickest and most effective mean of breeding through AI, 22.6 millions of crossbred cattle comprising of halfbreds and higher level of exotic inheritance have been produced in organized farms and rural households of different agro-climatic zones [11]. The crossbreeding in dairy cattle has relatively shown good results mainly under semi-intensive and intensive animal production systems. Accordingly, breeding policy for further genetic improvement of large existing crossbred cattle population under semi-intensive and intensive animal production systems is suggested below.

Under semi-intensive animal production system, it is advisable to restrict exotic inheritance between 50 and 62.5% through *inter-se mating* in crossbred cattle. Therefore, the F_1 crossbred females under semi-intensive production system should be bred with genetically superior progeny-tested crossbred males having exotic inheritance between 50 and 75%. Intensive (high input-high output) animal production system is mostly adopted by resource rich farmers in milk shed areas around peri-urban and industrial towns where good market for milk and milk products is available and adequate quantity of quality feed and green fodder resources exist. Under intensive production system, higher levels of exotic inheritance between 62.5 and 75% can be sustained. The F_1 females in the field should be bred with genetically superior progeny-tested males of exotic breeds with high progeny test index to produce progeny with 75% exotic inheritance. Further, the progeny tested crossbred males having exotic inheritance between 50 and 75% produced through *inter-se mating* can be used to sustain the exotic level between 62.5 and 75%. Holstein Friesian should continue to be the breed of choice in the irrigated plains and Jersey in hilly terrain and coastal areas for crossbreeding. The milk yield and milk constituents (fat and protein percentages) should be used as criteria for selection of crossbred bulls as well as import of frozen semen of exotic bulls of high transmitting ability [12].

The crossbreeding of non-descript zebu cows with semen of exotic dairy cattle breeds has resulted in enhancing milk production by 5 to 8 times to that of non-descript cows, reducing age at first calving and shortening calving intervals in first generation crossbred progenies. A well laid down breeding policy, along with availability of elite bulls in sufficient number, infrastructure on AI and animal health inputs, delivery

of services, programme monitoring and regulatory mechanisms, is required to sustain the improved productivity of crossbreds and check the decline in performance in subsequent generations [13].

Genetic improvement of non-descript cattle by grading up

The local non-descript low producing cattle are reared mainly under Low-Input Production System across the different agro-climatic zones where quality feed and fodder resources are not available in sufficient quantity. The farmers are not resource-rich and infra-structure facilities are also inadequate. Marketing facilities for sale of milk and milk products are poor. The non-descript cattle constituting more than 75-80% of total cattle population under this production system can be genetically improved by grading up using high genetic merit pedigreed and preferably progeny tested proven bulls of well known indigenous cattle breeds like Sahiwal, Tharparkar, Red Sindhi, Gir, Deoni, Hariana, Ongole, Kankrej etc. available in the breeding tract [14] which are maintained at several organized government and non-government farms for production of breeding bulls.

So far the impact of breed improvement programmes initiated earlier through grading up of the local non-descript cattle with improved indigenous breeds has not been very encouraging. This may be due to non-availability of adequate number of high genetic merit pedigreed or progeny tested bulls of indigenous breed, low production levels of indigenous breeds, irregular and short term basis breeding plan which could not wean away the farmers/breeders from using scrub bulls for breeding their herds [15]. Hence, this system of genetic improvement is failed to make any impact in improving the productivity of local non-descript cattle and fulfill their long term objective of transformation of nondescript cattle to the improved purebred breeds.

Therefore, for successful implementation of grading up programme of non-descript cattle with improved indigenous breeds, the adequate number of superior breeding bulls of different indigenous breeds need to be out-sourced for production of quality frozen semen and AI infrastructure networking should be strengthened. The bulls for this purpose initially should be produced from superior dams identified from organized farms and farmer herds which have more than 2000 kg as lactation yield for milch breed of Sahiwal, Tharparkar and Gir cattle and more than 1500 kg for dual type cattle breeds of Hariana, Kankrej and Ongole etc. These bulls should subsequently be genetically evaluated by large scale progeny testing programme through networking of organized farms and village herds [16].

Proper monitoring of grading up programme of nondescript cattle on regular and long term basis can improve the milk yield by 500 to 800 kg in the first generation. By use of zebu bulls of high transmitting ability for grading up subsequently in initial generations, milk yield can be improved to the extent of 5 to 10 % per annum. In a period of 5-6 generations of continuous grading up, the non-descript stock will also be transformed into well-defined purebreds [17].

Genetic improvement of indigenous cattle breeds by selective breeding

To meet the huge requirement of superior bulls of well-defined zebu cattle breeds and multiplication of their quality germplasm for enhancing the productivity of vast nondescript cattle as well as transforming non-descript to well define purebreds, it is necessary to undertake large-scale genetic improvement programmes in different zebu cattle breeds in their respective breeding tracts through selective breeding. The animals with high producing ability belonging to well-defined indigenous dairy and dual-purpose cattle breeds are maintained under intensive production system at organized farms and under semi-intensive management system at farmers' herds [18].

In the past, various selective breeding schemes for genetic improvement of indigenous cattle and buffalo breeds have been undertaken generally on single and small size herds in isolation manner. These programmes could not contribute towards identification and selection of adequate number of genetically superior proven bulls in accurate and intense manner which resulted insignificant amount of genetic progress over the years in most of the herds of indigenous cattle breeds due to small size, absence of rigorous selection of males and females, poor replacement rate and more involuntary culling of cows on the basis of traits other than low milk production, unplanned breeding programme and poor monitoring [19]. Therefore, it is suggested that the breed specific networking of organized farms and farmer's/breeder's herds should be developed to form a large associated test mate population for undertaking large scale progeny testing of breeding bulls. The closed herds could also be opened through two-way flow of superior germplasm from the breeding tract to nucleus herds and vice-versa. Thus, the adoption of open nucleus breeding technique will enhance genetic gain not only on organized herds but also in the farmer's herds [20].

Therefore, the existing herds of well-defined breeds need to be strengthened further and be designated as elite herds for production of superior bulls. The areas of the country where the indigenous cattle breeds need to be improved by selective breeding are: Gujarat state for Gir and Kankrej; Rajasthan state for Rathi, Nagori and Tharparkar; Haryana, parts of Punjab, Western U.P. and Rajasthan for Hariana, Maharashtra and parts of Karnataka for Hallikar, Amritmahal and Deoni; Tamil Nadu for Kangayam and Andhra Pradesh for Ongole. By selective breeding, it is expected that genetic improvement can be achieved ranging from 1 to 1.5% per annum in organized herds and 8-10% per annum in farmer's herds in initial generations. Such

breed improvement programme must form coordinating bodies for monitoring the germplasm production, performance recording, evaluation and selection of young bulls and testing their genetic merit through networking both at organized herds including progressive gaushalas maintaining indigenous breeds as well as farmer's herds under field conditions.

Genetic improvement of indigenous buffalo breeds by selective breeding

The relatively high yielding buffaloes of well-defined breeds are maintained under intensive production system at organized farms and under semi-intensive management system in farmer's herds in the breeding tracts of different buffalo breeds. To exploit the large degree of genetic variability between and within the buffalo breeds, the genetic improvement of buffalo herds in the country can be brought through selective breeding within breeds by net-working approach of progeny-testing of bulls associating multiple organized herds as well as farmer's herds under field conditions [21].

For effective implementation of such programmes particularly on large scale, existing organized farms of Murrah, Surti, Mehsana, Nili Ravi, Nagpuri, Bhadawari and Jaffarabadi buffalo breeds should be strengthened for production of breeding bulls. In certain pockets of states like Gujarat, Rajasthan and Karnataka, Surti is recommended to be the breed of choice; Murrah is generally the breed of choice in the states of Punjab, Haryana and Western U.P besides few pockets in Punjab where Nili Ravi has sizable population and it also needs to be improved through selective breeding. The genetic improvement in indigenous buffalo breeds for higher milk production, reduction in age at maturity, service period, dry period and calving interval will lead to higher economic returns to the farmers. It is expected that genetic improvement of 1 to 1.5% per annum in milk production will be achieved at organized farms by selective breeding, through networking of multi-herds of a particular breed and 8-10% per annum in farmers' herds through introducing germplasm of high yielding buffalo bulls [22].

Genetic improvement of non-descript buffaloes by grading up

The low producing, local non-descript buffaloes are generally reared under low to medium input production system in areas where feed and fodder resources and marketing facilities are moderately available. The production potential of low producing non-descript buffaloes can be increased rapidly through mating with superior sires of improved breeds like Murrah, Surti and Mehsana. Surti is recommended for Karnataka, Kerala, parts of Gujarat and Rajasthan, Nili Ravi for few pockets of Punjab, Murrah for Haryana, parts of western Uttar Pradesh and Punjab. In other parts of the country where sufficient feed and fodder resources are available, Murrah is recommended for grading up of medium body sized non- descript buffaloes [23]. The low producing non-descript buffaloes can be replaced with relatively high producing buffaloes conforming to the characteristics of well defined breeds through grading up with superior breeds in 5 to 6 generations [24]. It may be explored to collect semen from 50 % graded breed bull and distribute for field insemination in the places with inadequate management and feed / fodder resources for sustaining the improvement achieved in the first generation of grading up programme.

Advanced technologies for genetic improvement

It has been observed that livestock genetic improvement programmes are based upon the technologies developed in the areas of quantitative genetics and reproductive biology. These include methodologies for selection of females based upon their expected producing ability and young males based on their expected predicted difference using pedigree information, physical attributes and subsequently evaluating sires on the basis of their progeny performance etc. These coupled with Artificial Insemination and Embryo Transfer Technology for further improving the intensity and accuracy of selection could be utilized for improvement of cattle and buffalo herds maintained on organized farms and under field conditions [25]. Since large proportion of genetic gain is resulted through proper selection of superior breeding bulls, it should be ensured that the young bulls are the progenies of elite matings and subsequently be progeny tested on large test mate population associating multiple organized herds or farmer herds. Elite cows or she buffaloes for nominated mating may be chosen from organized herds and from farmers' herds through developing proper performance recording system under field conditions [26].

We require huge number of genetically superior breeding bulls along with adequate networking of AI and animal health infrastructure for implementing the large scale genetic improvement programmes on widely distributed population of cattle and buffaloes in the country. According to an estimate, to cover even 30% breedable bovine population in the country for breeding through AI as many as 1050 proven bulls of crossbred cattle, 5700 proven bulls of well-defined indigenous cattle breeds and 11400 proven buffalo breeding bulls are required. Outsourcing of large number of bulls/bull calves, selected on the basis of performance of elite pedigreed dams and progeny performance, is an uphill task in the absence of animal performance recording system under field conditions [27]. Different models on Networking of breed-specific institutional cattle and buffalo organized farms and large progressive farmer's herds for testing of large number of breeding bulls and introducing performance recording and progeny testing of bulls with active participation of farmers need to be planned [28]. National Project on Cattle and Buffalo Breeding

initiated by Department of Animal Husbandry & Dairying, Government of India has played a vital role in evaluation, production and dissemination of adequate number of genetically superior bulls and their frozen semen doses through involving various research and development organizations [28].

The advanced reproductive techniques such as Multiple Ovulation and Embryo Transfer (MOET) and embryo manipulation (splitting, sexing and cloning etc.) offer possibilities for faster multiplication of superior germplasm from highly selected elite donors and may facilitate to achieve the target producing large number of superior bull calves/bulls and their adequate number of quality semen doses. Emerging developments in the area of molecular genetics has also opened the new possibility of identifying and using DNA level variation and major genes for genetic improvement of livestock [29]. The molecular marker systems in animals (RFLP and micro satellites), genome maps, methods of detecting marker-QTL linkages and marker-assisted selection will be new tools used in breeding programme for enhancing the rate of genetic progress. Marker assisted selection (MAS) can be effective on the traits, which are expressed late in the life of the animal, or that are controlled by a few pairs of alleles such as longevity, fertility, resistance to certain diseases or defects of simple inheritance. This could be of great use in those traits in which the procedures of conventional selection have limitations in achieving efficiency or the results have not been satisfactory. The use of molecular techniques involves new opportunities and new challenges for building and using more predictive and efficient statistical models for livestock improvement. Therefore, integration of molecular markers with conventional breeding involving pedigree and phenotypic information evaluation is expected as future breeding tool for selection of animals [30].

Recommendations

In this context the following strategies are recommended for accomplishing the huge task of genetic improvement of cattle and buffalo genetic resources in the country:

* Establishment and strengthening of breeding services organizations (Centre/State level) for overall monitoring and implementation of breeding programmes.
* Infrastructure facilities such as establishment of AI centers, Animal Health Centers, milk procurement and extension centers fully equipped with trained man power can be provided to enlarge network of breeding facilities for covering large number of breedable bovine animals in the operational area.
* Integration of *In-situ* and *Ex-Situ* conservation programmes with breed improvement and development programmes. Establishment and strengthening of breed nucleus herds/bull mother farms, young bull rearing centers, semen collection and cryo-storage banks.
* Establishment of data bank to carry out activities on animal identification and performance recording linked progeny testing programme for selection of large number of high genetic merit bulls.
* Networking of breed-specific organized government/private cattle and buffalo farms and large progressive farmer's herds for testing of large number of breeding bulls and linking with performance recording and progeny testing of bulls under farmer's herds in village conditions.
* Adoption of open nucleus breeding system (ONBS) with or without MOET and other advanced reproductive techniques i.e. embryo splitting, embryo/ sperm sexing and cloning etc., for faster multiplication of superior germplasm and large-scale dissemination, Formation of the milk producer's co-operative unions/breed societies/NGOs for participation of farmers/ breeders in the activities on breed development and improvement as their own programme.
* Participation of non-governmental, voluntary and private sector organizations for delivery of animal breeding, health, marketing and extension services at the doorstep of farmers.
* Molecular genetic studies for identification of genes of interest (Milk quality and quantity traits, fertility, draft, disease resistance, adaptive traits) and marker assisted selection (MAS) as new breeding tools need to be explored for identifying superior animals and commercial exploitation of genetic potential of indigenous breeds.

Conclusion

Suitable selection procedures and breeding policies are the tools available for improvement of dairy cattle and buffaloes. A reorientation of cattle and buffalo breeding policy would be attempted with area specific approach backed up by appropriate programs addressing our concerns for indigenous breeds and draught animal power. A similar approach has been adopted in the National Project on Cattle and Buffalo Breeding. Indigenous cattle breeds accepted by common farmers shall be further developed through region specific and breed specific programs aimed at selection in the breeding tracts and supply of improved quality germ plasm on demand by farmers. Formation of breed associations for improvement of indigenous breeds shall be encouraged. Such associations shall be involved in production of quality male stock. An effective mechanism for providing disease free superior breeding bulls and quality semen for artificial insemination will be put in place. Breeding services could be provided at the farmer's door step level. Advanced animal breeding and reproduction technologies developed during the last few decades would be utilized to augment the genetic improvement of cattle and buffaloes. Consequently, it would be possible to

develop and bestow the dairy animals with efficiency and considerably high genetic potential.

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