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Crossbreeding systems of livestock

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Abstract
Crossbreeding is the mating of animals from different established breeds (Falconer and Mackay, 1996). It is mostly used to combine the desired trait of the parents in the offspring. It is effective because of heterosis or hybrid vigor- NAGA and Breed Complementarity- AGA. It is an effective means to utilize the non- additive genetic variance. Crossbreeding system works by increasing the frequency of heterozygotes at the expense of homozygotes. It is opposite to the phenomena of inbreeding depression. There are different methods of crossbreeding used in different species. Crossbreeding can be broadly classified into two types viz. regular and composite.
Regular system of crossbreeding includes specific (two breed, three breed, four breed, terminal) and rotational. Crossbreeding is used as a tool to improve the milk production in case of cattle and for wool and meat in sheep has been in practice for long period. Crossbreeding of zebu cows with exotic dairy bulls has increased the genetic potential of milk yield in non-descript zebu crossbred cows.

Keywords: Heterosis, breed complementarity, terminal crossing, rotational crossing

1. Introduction
Crossbreeding begins with the mating of two purebreds of different breeds [1]. This results in first-cross progeny, termed F1. There are three potential benefits of crossbreeding—heterosis, favorable breed combinations, and breed complementarity. For exploiting heterosis and breed complementarity, requires a well planned crossbreeding system. There are two basic genetic requirements for a trait to exhibit heterosis i.e. there must be genetic diversity between the breeds crossed and second is the presence of some non-additive gene effects for the particular trait involved. Crossbreeding causes more gene pairs to be heterozygous. In general, cross between animals of unrelated breeds exhibit higher levels of heterosis due to more heterozygosity than the cross between animals of more genetically similar breeds. So, the pre-requisite for crossbreeding to be effective is that the breeds involved in the cross must be genetically diverse [2]. The crossbreeding acts as an effective tool for the genetic improvement of animals. However, a number of factors determine the practicality and effectiveness of crossbreeding systems. These factors include –

- Herd size, market target, existing breeds in the herd.
- Management expertise, labor availability, grazing system, handling facilities.
- The number of breeding pastures and artificial insemination.
- Purchasing healthy, well-developed replacement females of appropriate breed composition can be the simplest and quickest way for producers, especially small operators, to maximize maternal heterosis in the cowherd and thereby effective crossbreeding.

2. Crossbreeding Systems in livestock species
Crossbreeding is a mating system in which animals from different established breeds are crossed. It is mostly used to combine the desired trait of the parents in the offspring. Crossbreeding is effective because of heterosis or hybrid vigor- and breed complementarity. Heterosis is governed by non- additive gene action while the breed complementarity is because of the additive gene action. Heterosis refers to the superiority of the crossbred animal relative to the average of its straight-bred parents whereas breed complementarity allows one breed's strengths to complement the other breed's weaknesses**.** Crossbreeding systems must be planned for each operation depending on herd size, potential market, level of management, and facilities. A long-term plan is necessary to gain maximum benefits from crossbreeding. There are also considerations such as whether to purchase or raise your own replacements. Purchasing crossbred F1 replacement females can be the simplest and fastest

method of obtaining maximum hybrid vigor as crossing a bull to crossbred heifers is simple and maximizes heterosis**.** There are three main types of crossbreeding systems terminal, rotational and composite [3].

3. Beef crossbreeding Systems

Crossbreeding in the commercial beef industry is an important management practice. Structured crossbreeding programs are utilized by beef producers to optimize productivity. Crossbreeding allows to utilize breeds that are from different, but complementary, biological types and also results in increased reproductive performance and calf weights. This results in a combined benefit of more calves to market that are heavier which translates into increased profitability. In beef cattle heterosis is most commonly utilized through crossbreeding. Crossbreeding in beef cattle can produce calves with enhanced reproductive, survival, longevity, fertility, growth, meat quality and disease resistance traits. For beef cattle three different types of crossbreeding system viz. terminal cross, rotational, composite are mostly used [4].

3.1 Terminal Cross

The simplest form of crossbreeding is a terminal cross. In this system, all offspring are marketed and replacement heifers are purchased from outside. If F1 replacement heifers (females that have100percent hybrid vigour for maternal traits) are purchased and are bred to bulls of a different breed, both cows and calves take advantage of heterosis. This system allows the most flexibility in choosing breeds to use. Replacement heifers can be purchased that are comprised of “maternal” breeds and bred to terminal or high growth breed bulls. This type system is optimal for many cow calf producers [5]. Terminal crossing can be done either using two breeds (two breed terminal) or three breeds (three breed terminal).

3.1.1 Two-breed Terminal

The two-breed terminal system is the most basic crossbreeding system available. The system crosses straight bred females with the bulls from another breed and the resulting offspring known as F1. All of the offspring from this initial cross are marketed, and replacement heifers are purchased. This system demands only one breeding pasture and also the labor and management are minimized. The progeny produced are highly uniform and marketable. The F1 heifers are sold as breeding females for other operations. This program is appropriate for herds of all sizes because only one sire breed is used, just one breeding pasture is needed, and replacement females are purchased. This is not a desirable system because it does not realize any heterosis in the cow since she is straight bred.

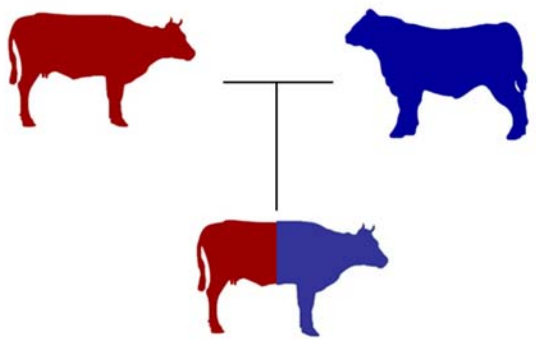

Fig 1: Two breed terminal cross

3.1.2 Three- breed terminal

The three-breed terminal system is identical to the two-breed terminal system except that the females are crossbred females (AxB) mated to sires of another breed (T). This terminal system has many advantages. It produces maximum hybrid vigor in the cow and calf. This is an excellent system because hybrid vigor is realized for both growth rate and maternal ability. Only one breeding pasture is needed, replacement females are purchased and all calves are marketed. Because replacement heifers are not being produced, sires can be chosen only on growth and carcass with no attention to maternal traits. This system can be used for herds of all sizes. The three- breed terminal system results in the most hybrid vigour of any crossbreeding scheme. This system results in 100 percent of both individual and maternal heterosis over the average of the parent breeds [6].

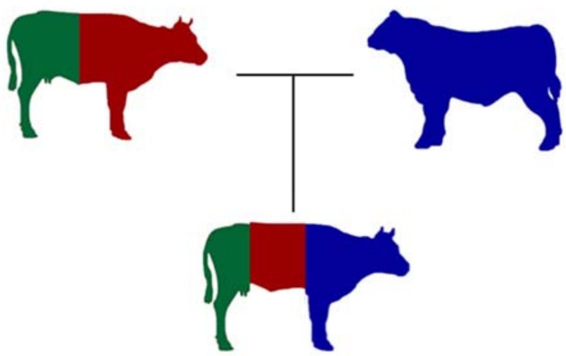

Fig 2: Three breed terminal cross

3.2 Rotational Crossing Systems

3.2.1 Two-breed Rotation/ Crisscross

Two-breed rotation is a simple crossbreeding system involving two breeds and two breeding pastures. A two-breed rotation is started by breeding cows of breed A to bulls of breed B. In each subsequent generation, replacement heifers are bred to bulls of the breed that is the opposite of their sire (Figure 3). Two breeds of bulls are required after the first two years of mating. The two breeds chosen should be comparable in birth weight, mature size, and milk production. This minimizes calving difficulty in first calf heifers and simplifies management. The two-breed rotation is an effective and relatively simple crossbreeding system that takes the advantage of individual and maternal heterosis. Considerations when using the two –breed rotation are breed type, resources available to raise replacement heifers, and size of cowherd. Biological type is significant because females are being retained that are sired by both breeds A and B. Both breeds should have maternal characteristic conducive to utilization as commercial females. Also, replacement heifers are retained in this system, which requires additional land, labor, and resources. Cost and availability of these resources need to be considered. The last consideration is size of the cowherd.

The system gives 100% of achievable heterozygosity in the first generation, 50% in the second, 75% in the third, and gradually settles down to a consistent 67% in succeeding generations [7]. The percent of genes from the two parent strains fluctuates, and for any one of the strains, alternates from 33% to 67% in alternate generations. This is no disadvantage in cases where the two types of crosses are very similar. However, in crosses between European and tropical cattle, these two types might perform quite differently. The System has the advantage that, since purebred males are used in each generation, very small purebred nuclei are needed to service a quite large commercial population. This advantage is enhanced if artificial insemination is used, and the system should therefore have some potential in cattle populations.

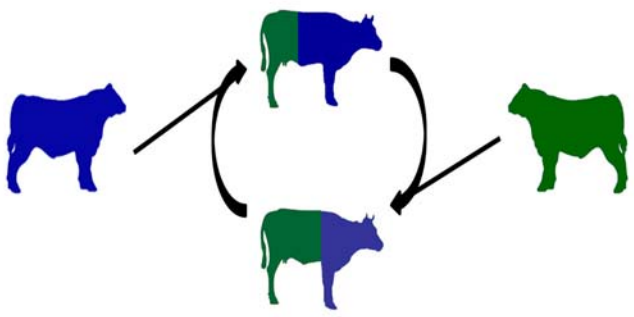

Fig 3: Two-breed rotation

3.2.2 Three-bred Rotation

The three- breed rotation is very similar to the two-breed rotation with another breed added. This rotation uses sires of breeds A, B and C. Breed A sires are mated to females sired by breed B, breed B sires are mated to females sired by breed C, and breed C sires are mated to females sired by breed A. Replacements are retained from within the herd, and three breeding pastures are needed. The primary benefit of a three-breed rotation over a two-breed rotation is increase in hybrid vigor. Disadvantages of the three-breed rotation are that an additional breeding pasture and breed of bulls must be maintained. In addition, management and labour requirements increase because of the additional complexity of using three breeds over two. As in the two-breed rotation, the three breeds used should be complementary with maternal characteristics conducive to the breeding female's role in a commercial herd. The three-breed rotation can be used with fewer cows; however, bull expenses per cow will be greater.

The minimum herd size is approximately 75 cows with each half being serviced by one bull of each breed [8]. Scaling of herd size should be done in approximately 75 cow units to make the best use of service sires, assuming 1 bull per 25 cows. Replacement females are mated to herd bulls in this system so extra caution is merited in sire selection for calving ease to minimize calving difficulty. Be sure to purchase bulls or semen from sires with acceptable Calving Ease (preferably) or Birth Weight EPDs for mating to heifers. Alternately, a calving ease sire(s) could be purchased to breed exclusively to first calf heifers regardless of their breed type. The progeny produced from these matings that do not conform to the breed type of the herd should all be marketed. Breeds used in rotational systems should be of similar biological type to avoid large swings in progeny phenotype due to changes in breed composition. The breeds included have similar genetic potential for calving ease, mature weight and frame size, and lactation potential to prevent excessive variation in nutrient and management requirements of the herd. Using breeds of similar biological type and color pattern will produce a more uniform calf crop which is more desirable at marketing time. If animals of divergent type or color pattern are used additional management inputs and sorting of progeny at marketing time to produce uniform groups may be required [9].

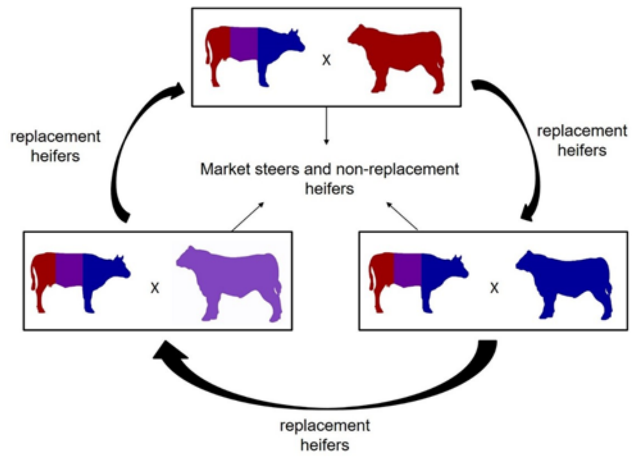

Fig 4: Three-breed rotation

3.2.3 Four- breed Rotation

The four breed rotation just like the other rotations, only with four breeds of sire utilized. Breed A sires are mated to females sired by breed B, breed B sires are mated to females sir by breed C, breed C sires are mated to females sired by breed D, and breed D sires are mated to females sired by breed A. Replacements are retained from within the herd, four breeding pastures are used, and four breeds of sires must be maintained.

3.3 Three-breed Rototerminal

A three-breed rototerminal system is an extension of the two –breed rotational system. It is also known as a two- breed rotation with terminal sire system. A percentage of the breeding females are placed in the two-breed rotation with terminal sire system. A percentage of the breeding females are placed in the two-breed rotation with terminal sire system. A percentage of the breeding females are placed in the two-breed rotation, and another percentage is mated to a terminal sire. The females in the two-breed rotation produce the replacement heifers, and the females in the terminal cross produce all market calves. The rototerminal system is essentially a hybrid-crossbreeding program using aspects of a terminal program and a rotational program. This system allows the breeder to produce all own replacements while making greater use of hybrid vigor in the terminal calves. Terminal sires can be selected for increased growth and carcass traits to maximize production from the cowherd.

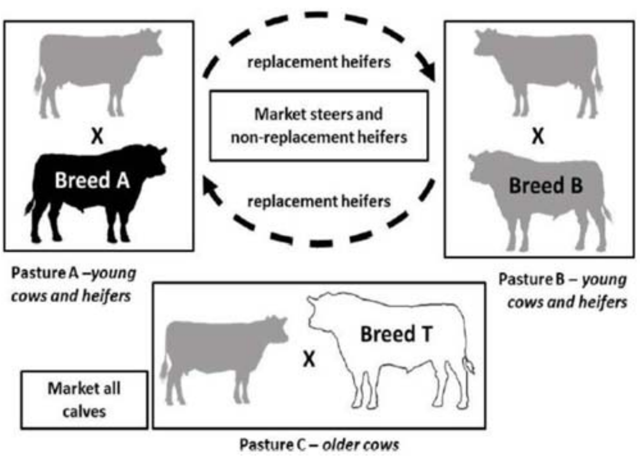

Fig 5: Three-breed rototerminol crossbreeding system.

3.4 Rotate Bull Every Four Years
This system requires the use of a single breed of sire for four years then a rotation to a second breed for four years, then back to the original breed of sire for four years, and so on. Breed fractions of cows and level of maternal heterosis will vary depending on sequence of production. Estimates of the range of retained heterosis are dependent on the number and breed make-up of females retained in the herd. Several assumptions are made when estimating the expected performance improvement and retained heterosis. In a two-breed rotation of bulls the minimum retained heterosis is 50% and assumes that over time the average breed fractions represented in the herd are equal (50% breed A, 50% breed B) with random selection of replacement females. However, depending on culling rate and replacement selection, this retained heterosis maybe as high as 67%, similar to a true two-breed rotation. The expected improvement in weaning weight per cow exposed is a function of retained heterosis will range from 12-16% for at two-breed system with bulls rotated every four years. Likewise, in a three-breed rotation of bulls every four years, the minimum expectation of retained heterosis is 67% assuming the animals stabilize at a composition of 1/3 of each breed. Again, depending on culling rate and replacement selection the retained heterosis may be as high as 83% which is similar to a true 3 breed rotational system.

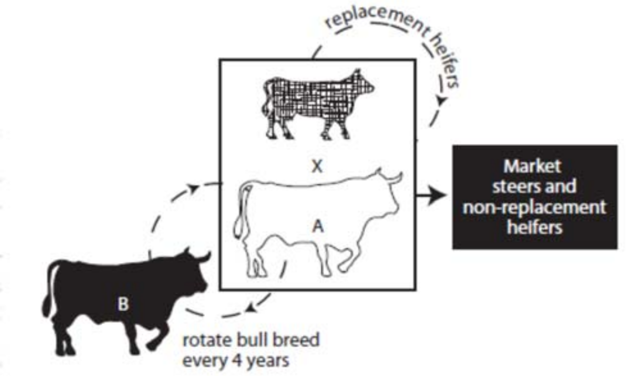

Fig 6: Rotate bull every four years

3.5 Composite Breeds
This system "blends" traits of economic importance from a number of breeds to create a composite which is then maintained as a straight-bred herd. Aside from the advantages of heterosis retention and breed complementarity, composite population breeding systems are as easy to manage as straightbreds once the composite is formed. The simplicity of use has made composites popular among very large, extensively managed operations and small herds alike. When two-, three- or four-breed composite are formed they retain 50%, 67%, and 75% of maximum calf and dam heterosis and improve productivity of the cowherd by 12%, 15%, and 17%, respectively [10]. Thus, these systems typically offer a balance of convenience, breed complementarity and heterosis retention.

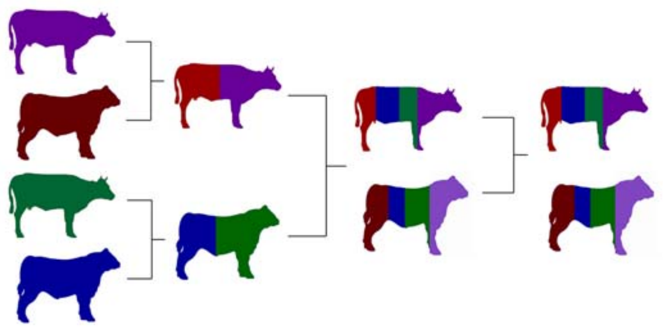

Fig 7: Four breed composite crossing

4. Crossbreeding systems for swine
4.1 Rotational cross
A three breed rotational uses three breeds of purebred boars, rotated in a consistent order, one breed for each generation. Offspring from each generation are used for market production as well as replacement gilts. Replacement gilts kept from the cross are bred to the breed of purebred boars used least recently

Advantages
- Maintain 86% heterosis in offspring and sows.
- Produce your own replacement gilts.
- System is easy to manage.
- Offspring are uniform as all are genetically the same.
- Most common crossbreeding system.

Disadvantages
Breed composition changes with each generation. If breeds used in the rotation are different in important traits. (i.e. milking ability, growth rate) changes in areas of performance can be different with each generation.

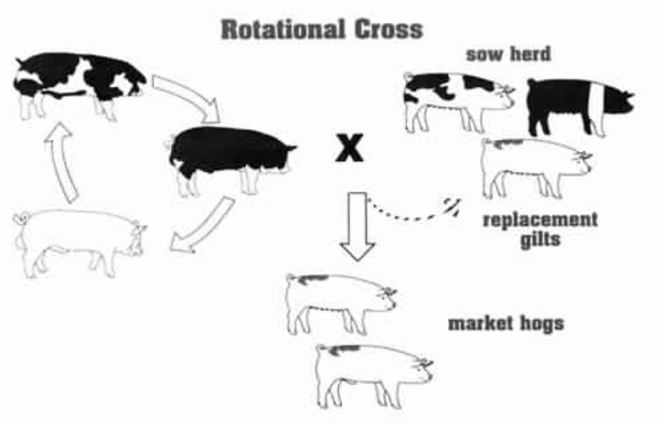

Fig 8: Rotational cross in swine

4.2. Terminal
In a terminal breeding system, a crossbred gilt (F1) is mated to a terminal purebred boar and all animals are sent to market. Replacement gilts are not kept from this mating and therefore must either be purchased or produced separately. Purebred breeds can be used in a specialized role (i.e. to produce only

females or only market hogs) and therefore the strong characteristics of each breed can be fully realized.

Advantages

- Maintain 100% heterosis in both the sows and market animals.
- Can take full advantage of each purebred breeds strengths.
- Uniform market animal as every animal produced is the same genetically.
- System is easy to manage if replacement gilts are purchased and all animals produced go to market

Disadvantages

- If F1 female is purchased, this is an additional cost and disease could possibly be introduced in herd.
- If F1 female is produced, it requires more management as two genetic pools must be maintained, one to produce replacement females and one to produce market animals.

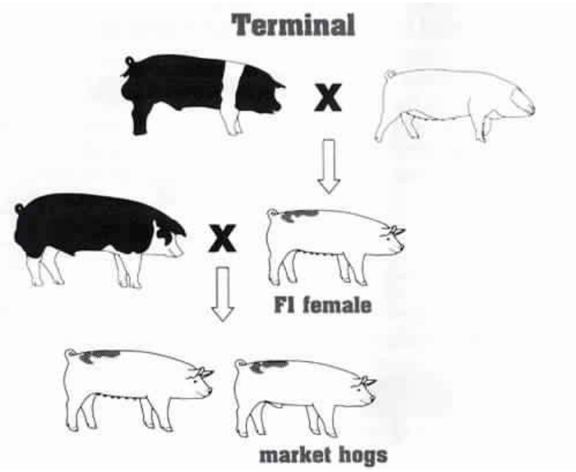

Fig 9: Terminal cross in swine

4.3. Rotaterminal

Rotaterminal combines the rotational and terminal breeding systems. In a rotaterminal, top females are selected and used in a rotational cross that produces replacement gilts. Maternal breed purebred boards are used in this rotation. The replacement gilts are then mated to terminal boars for market production.

Advantages

- Maintain 86% heterosis in sows and 100% heterosis in market hogs.
- Produce own replacement gilts.
- Replacement gilts are produced from top sows which mean better milking performance.
- Market animals are uniform as all are sired by same breed of boar.

Disadvantages

- Requires better management and breeding as it has two genetic pools, one producing replacement gilts and one-market animals.

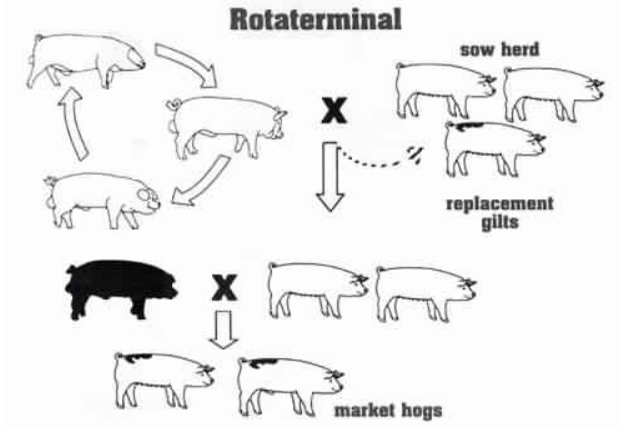

Fig 10: Rotaterminal system in swine

5. Crossbreeding system for sheep-

5.1 Simple cross

The most easily managed and widely used of these is the simple cross approach. In this system ewes of one breed are simply mated to rams of another complementary breed. The resulting offspring will contain 50% of their genes from each breed and take full advantage of heterosis. However, disadvantage is in this type of system is that no purebred replacements are produced and they must be purchased elsewhere.

5.2 Rotational System

Rams of two or three different breeds are used in altering generations when this plan is implemented. Heterosis increases with the number of different ram breeds being presented to the flock. However, this system increases management concerns by forcing ewes to be separated into different flocks during the breeding season. Also, variation in breed composition can create different managerial requirements among flocks, but this approach does generate its own replacements, resulting in little or no need to purchase ewes for this purpose.

5.3 Terminal system

In this approach rams of a specialized sire breed are mated to ewes from one of the above systems to produce terminally sired market lambs that express 100 percent lamb heterosis. This system is widely used to maximize meat production efficiency. Again, replacement ewes must be purchased elsewhere because all lambs are sent to market.

6. Conclusions

Crossbreeding is an effective tool for the genetic improvement of animals but a long-term plan is necessary to gain maximum benefits from crossbreeding. There are different crossbreeding systems available for the different species of livestock. In comparing crossbreeding systems, each system excels in some criteria, often at the expense of other criteria. Some systems sustain very high levels of hybrid and some take advantage of breed complementarity but cannot produce their own replacement females. A planned mating system is the nucleus of a successful crossbreeding program. The mating system should maintain heterosis at an optimal level and permit uninterrupted production of a uniform product from generation to generation. Matching the crossbreeding system to the facilities and environment is of utmost importance. Likewise, the choice of breed is important. The use of a crossbreeding system that produces offspring with better production efficiency can play a large part in the profitability to the farmers.

7. References

1. Falconer DS, Mackay TFC. Introduction to quantitative genetics. Dorling Kindersley Pvt. Ltd. Longman Group, Essex, UK, Edn, 1996; 4(1):253-258.
2. Buchanan DS, Northcutt SL. The genetic principles of crossbreeding. Great Plains Beef Cattle Handbook, 1996.
3. Tomar SS. Text book of Animal Breeding. Kalyani Publisher, New Delhi, Edn, 2004; 5:252-255.
4. Gregory KE, Cundiff LV. Crossbreeding in beef cattle: evaluation of systems. J. Anim. Sci. 1980; 51:1224-124.
5. Franke DE, Habet O, Tawah LC, Williams AR, DeRouen SM. Direct and maternal genetic effects on birth and weaning traits in multibreed cattle data and predicted performance of breed crosses. J Anim. Sci. 2001; 79:1713-1722.
6. Budak H, Cesurer L, Bolek Y, Dokuyucu T, Akkaya A. Understanding of Heterosis. KSU J. Science and Engineering. 2002; 5(2):68-75.
7. Cunningham EP, Syrstad O. Crossbreeding bos indicus and bos taurus for milk production in the tropics. In FAO animal production and health paper. 1987; 68.
8. Cundiff LV. Experimental results on crossbreeding Cattle for beef production. J. Ani. Sci. 1970; 30:694-705.
9. Berg RT. Genetics aid beef cattle breeding strategies in cattleman’s handbook for cattle conferences.1982; 8:7-15.
10. Willis MB. Daltons Introduction to Practical Animal Breeding. Edn 4, Wiley Blackwell, 1998.