

LITERATURE REVIEW

Breeding, the key to the survival on the earth, is a science concerned with predicting the consequences of selection, inbreeding, crossbreeding and devising optimum breeding policies for improving productivity. It is a continuous process with continuous efforts and with a definite support of Bio-metrical studies for genetic manipulation through selection, hybridization and population breeding approach.

Today, enough literature, on various bio-metrical aspects is available. Most of the bio-metrical principles are commonly employed in crop plants and animal husbandry and are also under use in silkworm breeding for the betterment of the sericulture industry. However, for the present investigation a brief resume of the relevant literature pertaining to the present work was mentioned.

An understanding of the nature and magnitude of gene effects controlling complex characters, like yield and yield contributing traits were very important in adopting appropriate breeding procedure. Fisher (1918) was credited with defining the genetic variability in terms of gene effect and further partitioning it into additive, dominance and epistatic components. Cockerhan, (1954) and Kempthorne, (1954) further separated the epistatic value into additive x additive, additive x dominance,

dominance x dominance interactions. Several statistical models had also been developed to analyse the inheritance of polygenic characters (Fisher, et al., 1932; Wright, 1935; Mather, 1949 ; Robinson, et al., 1949; Comstock and Robinson 1952). Jinks and Hayman (1953), Griffings (1956) and Kempthorne (1957) proposed the inheritance of quantitative traits and genetic nature of parents involved in diallel and line x tester populations.

Combining ability :

The concept of the terms "general and specific combining abilities" introduced by Sprague and Tatum (1942) which was useful in selecting the parents and desirable cross combination to be used in any breeding programme for the improvement of a trait. It also gave an idea about the extent of heterosis, nature and relative magnitude of additive and non-additive type of gene action in the expression of a trait. Griffing (1956,b) had described the methods of evaluating combining ability of parents and crosses of diallel progenies.

Arunachalam et al., (1984); worked on the heterosis in relation to genetic divergence and combining ability. On the basis of mean, range and standard deviation of the intra and inter-cluster divergence four classes were formulated. The class DC3, having intermediate divergence, was found to yield high magnitude of heterosis.

Later, a number of studies on combining ability and its genetic control for yield and yield contributing traits were reported in crop plants (Tyagi et al., 1975, 1978; Singh et al., 1974; Singh & Singh, 1980; Kumar 1977; Lal & Seth 1981, 1982; More, 1987; Debnath & Sarkar 1990; Singh & Singh 1990). Further, Das and Kumar (1974) worked on the genetic analysis of the protein contents in pea. Sanjeev Gupta et al., (1989) worked on the combining ability in bread wheat.

On the basis of combining ability of the parents in A. mylitta D Siddiqui & Sengupta (1993), selected the parents for hybridization and reported that low \times low gca yielded significantly high sca which was due to over dominance.

Combining ability on silk filament length in F1 multi \times bi hybrids (B. mori L.) were studied by Kantaratnakul et al., (1987) and obtained longer filament length by using multivoltine as female and bivoltine as males.

Heterosis and combining ability estimates were made for four characters of tasar silkworm by Suryanarayana et al., (1987) and inferred that the exploitation of hybrid vigour was due to non-additive gene action. Datta and Pershad (1988) formulated an 8 \times 8 partial diallel of multivoltine and bivoltine strains and confirmed that multi \times bi combinations were better than the bi \times multi combinations. A 6 \times 6 diallel crosses were carried out among bivoltine silkworm strains by Subbarao and Sahai (1989)

wherein additive gene action was noticed in cocoon yield, survival, SCW, filament length and denier. Shell weight, shell % and larval duration were reported to be governed by non-additive gene action. Reciprocal effects were also significant for shell weight, denier and larval duration.

Working in Marathwada conditions on genetic architecture of economic traits in some strains of mulberry silkworm, B. mori L. Tayade (1989) revealed high sca effects & higher magnitude of maternal effects in Multi x bi combinations. Vijayaraghavan & Das (1992) worked on heterosis and combining ability in multivoltine and bivoltine breeds of B. mori L.

Combining ability in seven parent diallel analysis was conducted by Kumar et al., (1994) in bivoltine silkworms for filament length and other quantitative traits. Variances due to both gca and sca were significant for filament length and effective rate of rearing (ERR), showing the importance of additive and non-additive gene effects. The variance due to reciprocals for filament length, ERR, SCW, SR% were significant possibly due to cytoplasmic factors in the inheritance of these traits.

Line x Tester :

The line x tester design, derived by Kempthorne (1957), provided information about general and specific combining ability of parents and at the same time it was helpful in estimating various type of gene effects (Singh & Chaudhary, 1979).

Further, the utility of line x tester design and the differences between diallel and line x tester mating design were described by Arunachalam (1974). Later, several workers had utilised this line x tester design for various purposes in agricultural crops : Pathak et al., (1989) in castor; Kadapa et al., (1989), Kadapa & Prajapathi (1990) in cotton. .

While working on the genetical traits of cocoon quality in A. mylitta Siddiqui et al., (1996) crossed 8 tasar lines with 3 testers in the form of Line x tester mating design and concluded that non-additive effects were predominant for cocoon shell weight, cocoon shell percent, length of filament, reelability percent.

In silkworm, information on line x tester analysis was scarcely available except the work of Subba Rao (1983) and Ghosh et al., (1995) for studying the combining ability in multivoltine x bivoltine silkworms in Bombyx mori L. and recommended some F1 hybrids for further exploitation.

Diallel analysis

In a work using inbred lines of honey bees with 2 representatives from the races Ligustica carnica and carcasica, a 6 x 6 half diallel was formed with 2 replications per cross by Oldroyd and Moran (1983) to see the weight gains. Block effects were nonsignificant and significant genotype effects were

partitioned into general combining ability (GCA) and specific combining ability (SCA) which were also significant.

Estimates of genetic components and their proportions for seed technological traits in Eri silkworm was worked out by Nagaraja and Govindan (1994) and inferred that pupation rate could be improved by adopting selection procedure.

In tropical tasar moth, A. mylitta D., attempts had been made to study the genetic architecture and gene action involving yield components by Jolly et al., (1969 & 1972) and recently by Siddiqui et al., (1988,a; 1988,b) and Sengupta(1991) wherein selection schemes were advocated on the basis of genetic advance, heritability (narrow & broad sense) and environmental variations.

In Japan and China, extensive genetic analysis on B. mori L., had been under taken. Gamo and Hirabayashi et al., (1983); Jeong et al., (1986); Long, (1987).

In India ,Krishnaswami et al., (1964) worked on the diallel analysis of indigenous multivoltine races of B. mori by using 2nd degree of statistics (W_r , V_r - graphs).

Combining ability had further been studied and used in mulberry silkworms by Sengupta et al., (1971, 1974, 1975); Nagraj et al., (1983); Jolly (1983); Subba Rao (1983); Datta (1984); Pershad et al., (1986); Tayade (1987), and Satenahalli et al., (1989) with a view to replace the poor yielding local races. Sreerama et al., (1986) analysed the data for combining ability and heterosis test with bivoltine races of Bombyx mori L.

for economic traits. Studies in diallel on combining ability among multivoltine x bivoltine silkworm was under taken by Datta & Pershad, (1988) for cocoon yield and other five basic independent characters wherein the values of gca (General Combining Ability) for all characters and the value of sca (Specific Combining Ability) for cocoon yield and filament length were highly significant.

Diallel analysis for cocoon weight in the breeds of silkworm, B. mori L. was worked out by Sarkar et al., (1991), which revealed that cocoon weight was controlled by one gene group. They also stressed that effective selection in segregating generation for cocoon weight might be possible because of high heritability of cocoon weight.

Satenahalli et al., (1989) worked on the 7 x 7 diallel crosses for the larval duration, pupal duration, moth emergence and fecundity in B. mori L., with the help of component and graphic analysis and reported the degree of dominance, presence of epistatic gene interaction etc.

Narasimharaju et al., (1990) reported the extent and nature of genetic variability in silkworm breeds, B. mori L. Mukherjee et al., (1994) studied on gene action in multivoltine mulberry silkworm B. mori. By using component and graphic analysis. They revealed that the parents were under the influence of an over dominance for most of the traits under study.

HETEROSIS

Hybrid vigour or heterosis is regarded as the superiority of offspring over the parents. The beneficial effect of crossing is, however, a more widely recognised phenomenon.

Genetic basis of Heterosis :

Many hypothesis had been put-forth to explain the genetic basis of heterosis. The most widely accepted genetic basis was the dominance hypothesis proposed by Devenport (1908), Bruce (1910) and Keeble and Pellow (1910), East (1936) based on the assumption that cross fertilizing species consisted of a large number of genetically different individuals, many of which carried deleterious genes concealed in heterozygotes.

East (1908) assumed that there must be physiological stimulus to development that increased with the diversity of the uniting gametes. This idea had been called 'single-gene heterosis', 'super dominance', 'cumulative action of divergent alleles' and 'stimulation of divergent alleles' (Whaley, 1952). The term most commonly used, however, was 'over dominance' and the hypothesis to which it applied was generally known as 'over dominance hypothesis' of heterosis. The idea of superior heterozygotes had also been advanced by Hull (1945). According to him this would be possible with dominant genes acting in a completely additive fashion only if inbreeds with no favourable dominants had a negative yield. The validity of this argument

depended upon additivity of effects between loci in the inter allelic interactions.

Accumulation of evidence that the dominance hypothesis, at least, in its simplest form, was inadequate to account for the heterosis actually observed in various species, had led to increased interest in the nature of heterotic loci and their relation to the selective advantage of heterozygotes.

Exactly what a "heterotic locus" represented in terms of physical structure was a matter of speculation. Mather (1956) believed that no distinction was possible between complementary gene action and/or complementary action of alleles.

Many investigators later considered the action of such heterotic complex loci to be equivalent to that of complementary genes introducing the specific effects that contribute to heterosis (Dobzhansky, 1952, 1953; Lerner 1954,a ; 1954,b). Shull (1909) coined the term "heterosis" to define increased vigour of the hybrids over parents. Tysdal et al., (1943) considered the yields of 28 different single cross hybrids between inbred lines of Alfa alfa.

Pioneering work of Toyama (1920) in hybridization in silkworm was a landmark in the history of sericulture. However, it was said that J.Fujimoto and J.Nakayama, in Nagano prefecture, made a cross in 1845, between bivoltine and univoltine silkworms and found that the hybrid was very vigorous which gained popularity not only in Nagano district but was also exported to Italy in 1872, (Yokoyama 1956).

Since then series of investigations had been carried on hybridization to study not only the gene actions involved and nature and magnitude of heterosis but also to exploit the hybrid vigour commercially both in mulberry and non-mulberry silkworms starting from inter-specific hybridization to crosses between various inbreed lines (Jolly *et al.*, 1974).

In Antheraea mylitta D., studies on hybridization and utilization of hybrid vigour for commercial purpose were started by Jolly *et al.*, (1969, 1972) followed by Bardaiyar *et al.*, (1976); Sengupta *et al.*, (1987), Siddiqui *et al.*, (1988,b) and Sengupta (1991). Siddiqui and Sengupta (1993) stressed on the exploitation of hybrid vigor in A. mylitta with special reference to using genetic diversity. In eri silkworm hybridization studies were conducted by Zhu (1986).

In B.mori L., marked improvement in several characters of economic importance was observed in Japan by crossing different Japanese, Chinese and European races (Toyama, 1920; Osawa and Harada, 1944; Harada 1961; Singh and Hirobe 1964; Hirobe 1968; Yokoyama, 1974; Orozco, 1976 . Tzenov *et al.*, (1992) worked on the expression of heterosis and degree of dominance displayed for some quantitative traits characterizing the food utilization in F₁ commercial crosses between Japanese and Chinese silkworm races and concluded that the rate of heterosis had an influence on the manner of feeding of parents and their F₁s and also the efficiency of conversion of the food supplied, ingested and

digested into body substance. The trend in mulberry sericulture to use hybrid seeds at commercial level though, had long been initiated yet continuous efforts were being made to exploit the hybrid vigour for various purposes (Sengupta et al., 1971, 1974, 1975; Nacheva, 1980; Petkov, 1980; Benchamin and Krishnaswami, 1981,b; Jolly, 1983; Benchamin et al., 1983; Datta, 1984; Strunnikov, 1986; Sohn 1987; Tayade, 1987; Hossain, 1987; Jolly, 1987; Midorikawa and Yokozuka, 1988; Subbarao and Sahai, 1989; Gupta et al., 1992; Ghosh et al., 1993; Ghosh et al., 1996).

Raju et al., (1988) compared single and three way cross hybrids for larval and pupal character. Rayar and Govindan (1990) showed that the three way crosses using pure Mysore as male component, revealed less larval period and further advocated that the "three way crosses" could be supplied to farmers during emergency. Singh et al., (1990) worked on hybridization to screen higher yielding characters. Similarly, Rayer et al., 1988; Ashoka and Govinda 1990; Das et al., (1994) measured the heterosis in the three way cross of B. mori L.

While describing the establishment of superiority of hybrids over the Japanese local varieties, Hirobe (1984) stated that the hybrid vigor was connected with "distance" between genera, species, races, varieties and strains. He was of the opinion that too much distant populations would lead to hybrid weakness while too close relation would cause little expression of hybrid vigor. Therefore, an intermediate or suitable distance between

the organisms would cause the phenomenon of hybrid vigor. Similar view had also been advocated by Ehiobu and Goddard(1990) while working with D. melanogaster.

Gupta et al., (1992) stressed the use of multi x bi hybrids of mulberry silkworm for commercial purpose during late Spring and late Autumn.

Heterosis in some indigenous and bivoltine breeds were reported by Subba Rao et al., (1992). Heterosis effect in multivoltine breeds were carried out by Ghosh et al., (1993).

Rajdan et al., (1994) identified region specific heterotic crosses of B. mori L. for J & K on the basis of combining ability studies and inferred that the high x low group produced maximum heterosis.

The relationship between the degree of heterosis and genetic divergence in B. mori was worked out by Sen et al., (1996) wherein the selected and genetically diverged parents were crossed in diallel fashion and later grouped into 4 classes. This classic work in silkworm revealed that the divergent group falling in DC₃ class contained higher probability of producing more heterosis as compared to other classes.

GENETIC PARAMETERS

" While Mendels' laws provided the basis for the analysis of quantitative traits they did not furnish the procedures for studying this complex and important segment of genetics. we have

had to built on the pioneering work of Galton, Haldane, Fisher and Wright for the necessary bio-metrical approaches to the studies in quantitative genetics".-quoted by Robinson (1966). Techniques from Mendel provided the methods for studying and utilising large distinguishable gene differences, most of which were of relatively minor importance in the breeding for improvement of economic species.

The mathematical derivations of genotypic variance and its division into additive, dominance and epistatic proportions were first provided by the work of Fisher (1918). Fisher, Immer and Tedin (1932) proposed an experimental approach for separating and measuring additive and dominance effects using second and third degree of statistic. Sewall Wright (1935) gave detailed division and designation of the genotypic variance into additive genetic variance, dominance variance and epistatic variation. The concept of partitioning of genotypic variance in animal breeding was found by Lush (1940 and 1949). Comstock and Robinson (1948) developed statistical designs to estimate the components of genetic variance using full and half sib-families developed from individuals of random mating populations.

The estimation of different parameters and their genetic interpretations had been worked out by Comstock and Robinson (1952), Johnson et al., (1955) Griffing (1956, b), Robinson (1966).

A useful measure for considering the ratio of genetic variance to the total variance is "heritability". Heritability in broad sense were the ratio of the total genetic variance to the total phenotypic variance and provides a measure of the overall importance of hereditary determination of ratio. Heritability, in broad sense had extensively used in the study of quantitative characters in animals. Lush (1940, 1949) had provided methods of computing heritability and summerised the available information indicating its usefulness in breeding programme. Burton and Devane (1953) worked on the heritability in Fescue.

Lush (1947) & Mather (1949) studied heritable variation and had further sub-divided it into that portion attributable to additive genetic effect and that due to deviations from the additive scheme. Lush (1949) and Panse (1957) proposed the use of the ratio of the additive genetic component of variance to total variance as a measure of the degree of heritability (narrow sense). While the information contained in the estimates of heritability remained extremely useful in the study of the inheritance of quantitative traits, the evaluation was more on evaluation of selection procedure through computations of expected progress. The formulation of the expected progress from the use of the selection schemes had been published by Robinson (1966). The fraction of the total variation which was heritable, termed as co-effecient of heritability (Lush, 1935, Johnson et al., 1955).

In recent years quite a good amount of information had been published on heritability in different insect species also. Heritability for the wing length and wing thorax ratio in *Drosophila* has been reported by Aguade et al., (1981). Mackay (1981), Sorenson and Hill (1982, 1983) estimated the heritability of abdominal bristle numbers on two sternites. Giesel et al., (1982) reported the heritability of egg production and longevity in wild, outbred stock of D. Melanogaster and D. Simulans, wherein the heritability of these characters varied from 18.9% to 91.1% and 56.0% respectively. Pyle and Gromko (1981) estimated the heritability of repeated mating and mating speed in D. melanogster, D. simulanse and D. pseudoobscura.

Roff and Mosseau (1987) reviewed the quantitative genetics of *Drosophila* and examined the early theoretical concept that the life history traits should have heritability lower than those in other categories (Fisher, 1930, 1958; and Falconer, 1981).

Friars et al., (1983) reported 0.16 ± 0.05 heritability for 21 days pupal weight in Tribolium casteneum.

Brandes and Moritz (1983) evaluated the heritability of learning behaviour in Apis mellifera. Collins et al., (1984) studied heritability of several characters, Oldroyd and Moran (1983) studied the heritabilities of worker characters in A. mellifera.

Moritz (1985) studied the heritability of post capping stage in A. mellifera and its relation to varroaosis resistant.

A review on the animal breeding literature was carried out by Sheridan (1988) between the estimated and realised genetic parameters to determine the utility of genetic parameter in the prediction of selection responses.

Heritability of 5 characters such as eggs/layings, SCW, SSW, SR% were computed in A. mylitta by Sen, et al., (1976) for 5 inbred lines and 5 eco-races. All the characters showed high heritability ranging from 78.19% - 99.09%.

Siddiqui et al., (1985) computed the broad sense heritability in A. mylitta for 9 commercial characters. They showed moderate estimates of heritability for moth weight, fecundity, potential fecundity, egg laying co-efficient larval weight and pupal weight.

Heritability ranged from 50.32% to 62.01% in these characters. While high estimates of heritability like 80.86%, 78.13% & 74.60% were obtained for cocoon wt., shell wt, & SR% respectively.

Sengupta et al., (1987) reported high to very high estimates of heritabilities for absolute silk yield, fecundity, effective rate of rearing (ERR), shell weight and SR% separately from 8 parents and eight single crosses of tropical tasar species. Similar results had also been observed by Siddiqui et al (1988, b) while working with 6 parents and their 15 one way crosses. Siddiqui et al., (1988 a) also computed broad sense and narrow sense heritability for absolute silk yield, fecundity, ERR, SCW,

SSW following formula of Mather and Jinks (1971). In a diallel population of A. mylitta, heritability in narrow sense ranged from 10.29% to 65.99% in these characters. Siddiqui et al., (1989) reported high heritability (broad sense) for these characters in a diallel population of A. mylitta.

Sinha et al., (1993) advocated the recurrent selection by studying the genetic variability in A. mylitta D

Nagaraju et al., (1994) studied the Genetic analysis of the seed technological characters in Eri silkworm, Samia cynthia ricini

In mulberry silkworm, Bombyx mori L., Nassirillaev and Abbasov (1980) reported heritability for cocoon weight ($h^2 = 0.149$ and $h^2 = 0.248$) in different stocks and $h^2 = 0.188$ and 0.378 for silk richness. Tsocheva (1981) obtained similar values of h^2 in out-bred population of B. mori L., though, in inbred populations this value was much, lower. High heritability for filament length was estimated by Petkov and Yolvo (1979, 1980) for particular rearing seasons (0.458 - 0.474) and while changing feeding methods h^2 was estimated between 0.689 and 0.918.

Ozdzenska and Kremky (1987) observed high values of h^2 for hatchability (0.966), Survival rate (0.724) and cocoon yield (0.546). They also reported moderate high h^2 for cocoon wt. (0.229), Silk richness (0.245) and shell weight (0.347) while lowest heritability was found for filament length and silk yield (broad sense).

Satenahalli et al., (1990) studied the quantitative traits in B. mori by applying 7x7 diallel mating design. Partial dominance was observed in pupal wt., pupal duration, moth emergence, single cocoon filament length and denier and over dominance was noticed in fecundity.

Additive gene action was operated for rate of pupation while a non-additive one was observed for pupal weight, pupal duration, moth emergence, fecundity and hatching. While working on some of the genetic parameters in B. mori L., Ghosh, et al., (1994) suggested for adopting indirect selection criteria for the improvement of cocoon traits and oviposition. Further, Ghosh et al., (1994) estimated broad sense heritability, genotypic and phenotypic correlation among male and female mulberry silkworm B. mori L. population separately. Sen et al., (1995) studied genetic parameters in B. mori and deduced that the parameters possessing heritability and genetic advance are governed by additive gene action suggesting high selection value which could be improved through mass selection.

On the other hand, the traits possessing high heritability with low genetic advance indicting prevalence of non-additive gene action. Therefore, family/progeny selection should be practiced for improvement of these traits.

Correlation studies

In breeding work, knowledge of correlation between different characters is of paramount importance. Hazel (1943) first demonstrated the estimates of genetic correlation.

The genetic correlation might be due to three different causes - (i) Pleiotrophy (ii) Linkage and (iii) Heterozygosity (Reeve 1953; Tallis, 1959; Mode and Robinson, 1959; Abe, 1969; Grossman 1970; Hammond and Nicholas 1972).

A series of studies on correlation between various traits were available in many insect groups. Phenotypic and genotypic correlations of egg, production and longevity in wild out-bred stocks of D. melanogaster and D. simulans had been worked out by Tantawy and EL-Helw (1966), Tantawy and Rakha (1964), Rose and Charles Worth (1981), Giesel et al., (1982), Rose (1984). Service and Rose (1985). An extensive review on Drosophila had been made by Roff and Mousseau (1987) and they had shown that genetic correlations between morphological traits, and between morphological and life history traits were all positive but between life history traits have variable signs. This supports the pleiotrophy hypothesis.

Collins et al., (1984) worked on the correlation for several characters in the honey bee.

In non-mulberry silkworms, significant positive correlation between pupal wt. and fecundity were shown by Miller et al., (1982) in A. polyphemus; by Singh and Prasad (1987) and

in Philosamia ricini by Kotikal et al., (1989). The correlation regression between pupal weight and fecundity in muga silkworm were studied by Bara and Sengupta (1991).

In A. mylittaD., Sen et al., (1976) reported highly positive and significant correlation between cocoon wt. and shell wt. ($r = 0.86$). Siddiqui et al., (1985) reported positive and significant correlation between shell wt. and cocoon wt.; shell wt. and larval wt.; shell wt. and moth wt.; both at phenotypic and genotypic level. Siddiqui et al., (1989) reported positive and significant correlation between fecundity and cocoon wt. fecundity and silk yield, cocoon wt. and shell wt., cocoon wt. and silk yield and shell wt. and silk yield, at phenotypic level and genotypic level in a half diallel populations of A. mylitta D.

Sufficient references are now available on correlation studies between various quantitative characters in B. mori L. Legay (1961) reported correlation between various quantitative characters. Netaraj and Ganesh (1969) worked on the inter relationship between cocoon wt. and shell weight in different breeds. Samachari et al., (1980) studied the correlation between cocoon wt. and pupal wt., shell wt. and egg weight. Petkov (1981, a) observed negative phenotypic correlation between cocoon wt. and silk richness. Petkov (1981, b) reported high and positive correlation between cocoon shell weight ($r = 0.679$ and 0.681). Oshiki and Sato (1986) showed the relationship between egg size and manifestation of quantitative characters, while Long

and Petkov (1987) studied the correlations among quantitative characters. On the other hand, Ozdzenska and Kremky (1987) observed positive and significant genetic correlation between cocoon wt. and silk richness ($r = 0.76$), between survival rate and cocoon yield per 1 gm of egg ($r = 0.92$). He also reported highly negative and significant correlation between hatchability and number of eggs per gm and zero correlation between hatchability and survival rate. Heritability, genotypic, phenotypic and environmental correlation in out-breed population of mulberry silkworms B. mori L., were estimated by means of Hierarchical analysis of variance by Ozdzenska and Kremky (op, cit). Rajanna and Reddy (1990) studied the cocoon productivity traits such as cocoon wt, pupal wt. shell wt. and shell percent on the basis of Vth instar 5th day larval weight in tropical multivoltine and bivoltine race. Jayaswal et al. (1991), and shaheen et al., (1992) worked on the correlarion between female pupal weight and fecundity in bivoltine silkworm of B. mori L.

In bivoltine silkworms genotypic and phenotypic correlations in quantitative traits were reported by Giridhar et al., (1995) and inferred that cocoon weight, shell weight, filament length and denier could be considered as selection criteria for improvement of cocoon yield.

Path coefficient analysis

Yield is the multiplicative end product of many factors which jointly or singly influence it . Wright (1921)

developed the path co-efficient analysis technique by which the extent and nature of direct and indirect effects of the component characters could be understood. The method was utilised later by Dewey and Lu (1959) in crested wheat grass. In the field of sericulture by Sen et al., (1976) and Siddiqui et al., (1989) in A. mylitta D. Genetic variability and path coefficients among filament length, denier, reelability % and shell weight & shell ratio in A. mylitta D. were worked out by Siddiqui and Sengupta (1994) on the requirement of breeding aims

Yan (1983), Yang (1987), Yan (1988) and Kamili et al., (1995) worked out on the cause and effect relationship on various quantitative traits in mulberry silkworms in B. mori L. The relationship among different characters of B. mori L. were analysed with the method of path co-efficient by Li w (1992).