HETEROSIS AND STABILITY ANALYSIS IN MULBERRY (*Morus*, spp.)

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DEPARTMENT OF SERICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
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HETEROSIS AND STABILITY ANALYSIS IN MULBERRY *(Morus, spp.)*

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Dedicated to

My

Loving Mother

"Sharadha"

DEPARTMENT OF SERICULTURE

UNIVERSITY OF AGRICULTURAL SCIENCES

BANGALORE

CERTIFICATE

This is to certify that the thesis entitled "**HETEROSIS AND STABILITY ANALYSIS IN MULBERRY (*Morus* spp.)** submitted by **Mr. RAVI, K.N,** for the degree of **MASTER OF SCIENCE (SERICULTURE)** of the University of Agricultural Sciences, Bangalore, is a record of research work done by him, during the period of his study in this University under my guidance and supervision and the thesis has not been previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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(RAVI, K.N)

CONTENTS

LIST OF TABLES

(Contd ....)

LIST OF TABLES

(Contd ...)

LIST OF TABLES

(Contd ...)

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

I INTRODUCTION

High yield with low inputs has been the main objective of agricultural technology from time immemomorial. The same holds good for mulberry cultivation. This objective attains greater importance for success of sericulture industry since the silk'worm Bombyx mori L., has universal preference for mulberry (Morus spp.) as food plant. The mulberry plants fall under the genus Morus of family **Moraceae.** The number of species belonging to the genus is more than twenty. Genus Morus is native to Indo-China and widely distributed in the lower sub-Himalayan region upto an elevation of 2100 M above mean sea level covering both the temperate and sub-tropical regions of the northern hemisphere. The identity and nomenclature of the species are confusing as they are highly heterozygous and show, great diversity in morphological characters.

The world wide silk demand is increasing day by day and India has a great potential of increasing its cocoon production to a considerable extent by popularising the sericulture in the hither to unknown regions and at the same time evolving improved strains of silkworms and mulberry varieties.

India ranks second among the silk producing countries of the world (10,550 tonnes) and having an area of 2,21,603 hectares under mulberry. Karnataka produces about 60 per cent of the countries raw silk production (49.70 lakh kgs) by having 1,40,456 hectares of area under mulberry cultivation. In recent years much emphasis has been given to produce higher quantity of superior quality raw silk to compete in the international market (Anon., 1988 a). To achieve this goal efforts are being made to increase the production of good quality mulberry leaves which has a direct influence on the quality and quantity of raw silk produced.

Cross pollination is the rule rather than an excemption in mulberry. Due to the heterozygous nature of the plant the segregation of characters takes place in F_1 generation itself of the population and perennial nature are the limitations for the improvement of this crop. The variability is quite widespread in open pollinated population giving enough scope for improvement using conventional methods of breeding. Not enough information is available on biometrical approaches to assess the genetic diversity in this crop which is a pre-requisite for a sound and successful breeding programme. For mulberry, the aim of its breeding and selection is mainly concentrated on the foliage. This is the major difference between the other fruit trees and cereals. To meet the breeding objectives large scale, long-ranging breeding programmes are necessary for which an adequately conserved, broad spectrum, genetic variability is a pre-requisite.

Since mulberry can be grown or cultivated throughout the year, attempts have been made to identify the suitable genotypes for different environments. In order to achieve this goal breeder should know stability of different genotypes across the environments.

Normally genotypes exhibit a wide range of variation within and between environments because of genotype-environment interactions. This may cause differences in relative ranking of varieties when they are compared over a series of environments. As a result, establishing significant superiority of a genotype becomes difficult due to the interactions. Although stratification of environments has been used effectively to reduce the genotypic-environmental interactions, it may not be pragmatic since fluctuations across the environments will be of considerable magnitude. Yet other tool in the hands of plant breeders is to identify stable genotypes that interact less with environments in which they are grown. Since, stability of performance or the ability to show a minimum of interaction with the environment is a genetic phenomenon, planning for preliminary evaluation to identify stable genotypes of wider adaptability or productive genotypes for a specific environment is imperative.

Heterosis or hybrid vigour is the increased vigour, growth yield or function of a hybrid over the parents, resulting from the crossing of geneticaly diverse individuals. The exploitations of the hybrid vigour is being extended to many crops following its success in crops such as maize, bajra and onion. Hybrid vigour is less exploited in Morus spp., hence the present study was taken up to exploit heterosis and to identify stable genotypes across the environments.

The present study was conducted with the following objectives:

1. To find the yield variability between F_1 hybrids as compared to popular varieties in different harvests;
2. To estimate the standard heterosis of F_1 hybrids for leaf yield;
3. To assess the hybrids for stability for leaf quality characters over seasons and
4. To identify stable plant characters in mulberry as selection criteria for leaf yield.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The literature relevant to the main objectives of the study have been comprahensively reviewed in this chapter and has been presented under the following headings:

1. Studies on genotype X environemnt interaction and its importance;
2. Studies on stability models and parameters;
3. Studies on stability in <u>Morus</u> spp. and related crops;
4. Heterosis;
5. Heterosis in <u>Morus</u> spp. and related crops and
6. Variation for biochemical composition of leaves.

2.1 Studies on genotype X environment interaction and its importance

The complete meaning of the term 'Phenotype' was first explained by Johannsen (1909) which he related to the appearance or form arising as a result of interaction of genotype, the genetic constitution of the organism and the environment in which it is grown. He was the pioneer in profounding the importance of environment in the development process. The existence of genotype X environment interaction was for the first time reported by Fisher and Mackenzie (1923) from the results of a varietal trial on potato.

Sprague and Federer (1951) showed how the various components could be used to separate out the effects of genotype, environment and their interaction in equating the observed mean squares in ANOVA to their expectation on the random model.

Allard (1961) observed relationships between genetic diversity and consistent performance in different environments with pure line populations being less stable in productivity than mixed populations owing to the lack of population buffering in pure lines.

The genotype X environment interaction is usually present irrespective of whether the material under test is a pure line, hybrid or a top cross. This intraction reduces the progress of selection (Comstock and Moll, 1963).

Allard and Bradshaw (1964) reviewed in detail, focussing the implications of the genotype X environment (GE) interaction in applied Plant Breeding. Further, they classified different types of GE interactions and have discussed the basic causes of adaptations. They have also categorised environments into predictable and unpredictable types.

Eberhart and Russell (1966) noticed the importance of genotype X environment interaction in their study and developed a model to partition the total variability due to

GE-interaction into predictable and unpredictable sources of variation.

Breese (1969) opined that the GE interaction is a challenge in obtaining fuller understanding of the genetic control of variability, as interaction poses serious problems in interpreting evolutionary trends and rationalisation of policy and procedure in breeding for improved performances in an economic crop.

2.2 Studies on stability models and parameters

2.2.1 Stability models

Having realised the importance of GE-interactions many Statisticians and Geneticists have developed several biometrical models to analyse the stability of a genotype. Such models have been discussed critically and reviewed comprehensively by several workers (Knight, 1970; Freeman, 1973; Hill, 1975; Westcott, 1986; Gautam et al., 1986).

The stability models are basically described through the procedure adapted by Yates and Cochran (1938) and the model is as follows:

$$Y_{ij} = \mu + d_i + e_j + G_{ij} + e_{ij}$$

where,

Y_{ij} = Observed performance of the i^{th} line (i= 1 ..... v) in the j^{th} environment (j = 1,........ n)

μ = The grand mean over all lines and environments

d_i = The additive genetic contribution of the line calculated as the difference between the u and the mean of its line averaged over all environments (d_i = 0).

e_j = The additive environmental contribution of the j^{th} environment (e_j = 0)

G_{ij} = The GE interaction of the i^{th} line in j^{th} environment. (G_{ij} = 0)

e_{ij} = The error attached to the i^{th} line in the j^{th}. environment.

In the joint regression approach, the phenotypes regression co-efficient is estimated. To estimate this phenotypic regression co-efficient, for a particular genotype, its Y_{ij} values are regressed on to the mean of the j^{th} environment i.e., $\mu+e_j$. This approach is effect in regressing e_j+G_{ij} as the dependence variate against e_j as the independent variate. If a linear relationship is established betweent these two variates, than $G_{ij} = \beta ie_j + \beta i_j$, where β_i is the linear co-efficient of the i^{th} line and

d_{ij} is the deviation from the fitted regression line of the i^{th} line in the j^{th} environment. Although this approach was described by Yates and Cochran (1938), it came into wider use only after Finlay and Wilkinson (1963) in Australia employed to analyse 277 Barley varieties for their stability (Hill, 1975).

The linear regression approach was also used by Eberhart and Russell (1966) and they regarded the deviation from the regression line as the important component of varietal stability. The model developed is as follows:

$$Y_{ij} = \mu + \beta_i I_j + d_{ij} \quad (i = 1,2,.... t \text{ and } j = 1,2,....s)$$

where Y_{ij} = mean of the i^{th} variety in j^{th} environment.

μ = Mean of all the varieties overall the environments.

β_i = The regression coefficient of the i^{th} variety on the environmental index which measures the response of this variety to varying environments.

i_j = The environmental index which is defined as the deviation of the mean of all the varieties at a given location from the overall mean.

$$\frac{E_i Y_{ij}}{t} \qquad \frac{E_i E_j Y_{ij}}{t_s} \quad \text{with} \quad E_j I_j = 0$$

d_{ij} = deviation from regression of the variety of j^{th}. environment.

2.2.2 Stability parameters

To avoid the deficiency of conventional analyses in quantifying GxE interaction of individual genotype, many regression models have been proposed.

A stable genotype has been defined in many ways by different workers based on stability parameters considered by them.

Lewis (1954) defined the phenotypic stability as the ability of an individual to produce a narrow range of phenotype in different environments. He suggested a simple measure of phenotypic stability which he termed as stability factor (SF). Accordingly, stability factor for the i^{th} genotype is given by the formula

$$S.F. \frac{\bar{X}\ HE}{\bar{X}\ LE}$$

where $\bar{X}$ = mean

HE = High yielding environment

LE = Low yielding environment

A unit value of stability factor indicates maximum phenotypic stability in this computation.

Finlay and Wilkinson (1963) suggested that the stability parameter of a genotype based on its phenotypic regression coefficient (b_i). A genotype with a unit 'b_i' value higher mean yield (X_i or μ_i) is said to be a stable variety for a range of environments. As the mean yield decreases, genotypes with 'r' low slopes are regarded as being adapted to favourable and unfavourable environments respectively.

Eberhart and Russell (1966) proposed stability parameters to describe the performance of a variety over an array of environments. They showed that the regression of each variety on an environmental index and function of the square deviation from this regression would provide useful estimates of cultivar stability parameters. They consider the ideal variety as the one with a high mean (μ_i), regression $b_i = 1.00$ and $S^2 d_i = 0$ (mean square deviation from regression). Breese (1969), Tai (1971) and many others in recent years have discussed the utility of this model in predicting the relative performance of a population over years and locations to find out differences in stability.

Joppa _et al_. (1971) used the Eberhart and Russell model and estimated the yield stability of the selected spring wheat cultivars in the uniform spring wheat nurseries, for ten years and inferred that the use of regression analysis of such data could materially assist the plant breeder in arriving at the decision regarding the release of the cultivar.

Luthra and Singh (1974) and Verma and Virk (1983) compared some stability models and parameters. They have inferred that relative rankings of the genotype in Eberhart and Russell's and Perkins and Jinks models would be same.

2.3 Studies on stability/GE interaction in mulberry and related crops

2.3.1 Stability studies in mulberry

Sarkar et al. (1986) studied yield stability in mulbery. Twenty strains of mulberry were selected from 120 lines that had been tested in Berhampore for four years (1980-83) in replicated trial with 90 x 90 cm spacing. The analysis was done using Finlay-Wilkinson model and results indicated that S 1864, C 2010 and C 2028 has greater regression coefficient and these were the best yeilders for the high leaf yield and had below average stability. Strains S 1870, C 1757, C 2026 had lower regression coefficient values than one and had above average stability.

Bari et al. (1990) studied leaf yield performance of six open pollinated selections and two improved varieties of mulberry under four environmental conditions in order to evaluate their relative stability and response to the environmental fluctuations. Results showed that S_3 (environmental index) was the only and most favourable season as indicated by the positive and high environmental index value. The season S_1 (environmental index) was the worst and most unfavourable for leaf production in mulberry. S-17 and S-58 though possessed higher mean yield had $S^2 d_i$ value high as a result these strains proved to be unstable. S_{31} and S_{47} had the high mean yield and regression coefficient (b_i) was fairly equal to one, but their $S^2 d_i$ was too high. Hence these were also proved to be unstable. S_{33}, S_{35} and BSRM-19 were found to be stable in yielding ability because $S^2 d_i$ value was low and the regression coefficient was almost equal to unity.

2.3.2 Stability studies in related crops

Jung et al. (1980) studied sixteen varieties of flue-cured tobacco at three localities in South Korea for nine characters. BY 104, a mid season to late variety was the most adaptive, exhibiting the highest yield and average stability. Speight-G33 variety had below-average stability combined with a relatively high yield. Effects due to locality were significant for eight of the nine characters. Genotypic variance was generally higher than the variance due to genotype X locality interaction effects. Yield was positively correlated with days to flowering, leaf area per plant and length of the longest leaf.

Galvez (1981) evaluated six lines of sugarcane at two sites over three environments after a 6x3x2 factorial analysis from which genotype X environmental interactions were proved to be significant. The Eberhart and Russell stability model was applied, genotypes CP 5248 and Ja10-5 proved to be stable.

Murthy et al. (1982) evaluated a set of ten mutants or mutant-derived flue-cured tobacco lines obtained through irradiation and treatment with ethyl-methane sulphonate of Delerest, Hicks and Virginia gold at three sites for yield of cured leaf, bright leaf and total bright leaf equivalent. The lines differed significantly for cured leaf and bright leaf yields and genotype X environment interactions for all three traits. Line MDS_2 was stable at all sites and GSH_3 and MSD_{13} gave good yields under favourable conditions.

Mivra et al. (1983) studied height and its inter-plant variation. It differed significantly among the twelve *Nicotiana rustica* lines in fourteen environments (combinations of years, sowing dates and plant densities) in which a lines were grown. Line X environmental interactions were also significant for height and its inter-plant variation. Rank correlation analysis showed that height and its inter-plant variation were each genetically independent of their sensitivities to the environment. The linear sensitivity of inter-plant variation was positively correlated with the linear and non-linear sensitivities for height. It is suggested that inter-plant variation in height may have caused by phenotypic plasticity to micro-environmental variation within a given environment but also by developmental instability.

Deswal and Sangwan (1985a) studied fourteen varieties of sugarcane for stability. While, CP 36-105 gave high sugar yield and Co-7717 was most responsive to environmental differences in terms of cane yield.

Deswal and Sangwan (1985b) evaluated thirten varieties of sugarcane in three years. At one site, genotypic differences and genotype X environmental interaction effects were highly significant. CO-7314 line gave the highest yields each year, Co-1148, the second highest yielder was the most stable.

Rao and Rahaman (1985) studied seven varieties of sugarcane. Data on milliable canes per plot, yield per plot and juice sucrose per cent revealed that genotype X environmental interactions for all characters CO-7508 could prove stable in North Telangana.

Bonilla and Javier (1986) studied six varieties of flue-cured tobacco in six localities in North-Western Luzon, Philippines over two seasons. Genotype X environmental interactions were detected for days to flowering, height, number of harvestable leaves, cured weight and grade index. Though varieties were adaptable to a wide range of environments, Coker 258 was specifically adapted to favourable environments on the basis of grade index and number of harvestable leaves, varietal stability differed among characters. On the basis of the 'b_i' parameter alone, all the varieties, except Coker 258 were stable. Conclusions were reliably arrived at using b and S^2d_i simulataneously.

Rao <u>et al</u>. (1986) studied four promising lines and IV, DG-3 of Natu tobacco at four sites from 1980 to 1983. Genetic differences in cured leaf yield between genotypes and variation due to regression of genotypes in different environments were significant. Lines II 435 and II 426 were the highest yielders and were stable over environments.

Tsai (1986) studied twenty two varieties of tobacco. All the quantitative traits studied varied according to environmental conditions (modificatory variation). The most stable trait was the number of leaves, while leaf size was less stable. Early and mid season varieties exhibited less variation in yield than late varieties.

Bowman et al. (1986) evaluated nine cultivars of flue-cured tobacco at four locations in North Carolina, USA between 1978-87 in a total of 20 years X locality environments. A desirable cultivar was considered to be one in which yields were good in unfavourable environments with a high grade index, a regression coefficients greater than one for grade index and high leaf value per quintal. Cultivars at the low end of the scale for alkaloid acceptability corresponded to these criteria more closely than did cultivars in the middle or top end of the scale.

Nagarajan and Ethirajan (1987) evaluated twelve sugarcane varieties grown over two soil types. Components of stalk yield and quality showed sizable non-linear genotype X environmental interactions. Overall CO-419, CO-1148 and CO-975 were stable for stalk and sugar yields, 300 days after planting (DAP) but only CO-1148 was stable for both the characters after 360 DAP.

Ho and Chang (1987) studied fifteen varieties of sugarcane grown in four regions of Taiwan over two crop years. Genotype X environmental interactions were significant for all traits in both main and ratoon crops. ROC_9 performed well in both crops and showed high stability compared to the popular varieties ROC_5 and F_{160}.

Singh and Rai (1989) evaluated nine sugarcane varieties having four different origins at maturity for cane yield and sucrose content of juice over three years. Both characters differed significantly between varieties and environments (years). BO 91 (from Bihar) and Colk F112 (from Lucknow) had a high phenotypic index indicating stability in different environments. COS 786 and COS 776 (from Shahajahanpur) had low yields with a negative regression coefficient. They were considered stable for yield but unresponsive to environmental changes. BO 70 and BO 101 (from Bihar) showed stability for juice sucrose content but CO-7330 (from Coimbatore) and Colk-7711 (from Lucknow) gave good results only under favourable conditions.

Tripathi et al. (1989) evaluated fourteen elite varieties of sugarcane from sub-tropical regions (Punjab, Haryana and Uttar Pradesh) for yield components using two crops of the normal planting seasons during 1980-82, two late crops and two ratoon crops. Colk-7701, COS-767, COS-802 and COJ-75 had good cand yields and were the most stable. Colk-7701 and CO-1148 were responsive to the better environment (normal planting date) COS-687, Colk-7701 and Colk-7708 did well under unfavourable conditions for leaf yield, CO-1158 had good yield and was adapted for the favourable environments.

2.4 Heterosis

Hybrid vigour, the manifest effect of heterosis has been one of the most interesting topics in the science of genetics and plant breeding. Studies on hybrid vigour in the beginning were mainly of academic interest. Various hypotheses have been advanced to explain the phenomenon. Theory of heterozygosity (Shull, 1908 and 1911, East, 1908), theory of dominance (Devemport, 1908; Bruce, 1910; Keeble and Pellow, 1910) theory of intra-allelic interaction (East, 1936) the super dominance or over dominace hypotheses (Hull, 1945) and physiological hypotheses (Ashby, 1930, 1932 and 1937) are some among the several hypotheses putforth. Consensus is that one or several of these phenomena act alone or in combination in any given situation of heterotic effect.

2.4.1 Heterosis studies in mulbarry

Hybrids of mulberry obtained by vegetative and sexual hybridization differed morphologically from sexual hybrids between the same components. The former were characterised by high heterotic vigour (Hakimov, 1959).

Abdullaevik et al. (1962) studied the offspring (F_1) of selected varieties of mulberry and it was begun in 1956 in order to isolte highly productive varieties which could be propagated from seed. The female varieties Azar-toot, Sikhagez-toot, Azerbaidzhanskaya No 82, Ukrainskaya No 9 and Kinryu and the male varieties Cattaneo and Azerbaizhanskaya No 38 were taken as a parental lines. The inter and intra-specific hybrid combinations of cultivated varieties of mulberry signficantly surpassed the most widely distributed local variety of mulberry (Dzhir-toot), with respect to growth and development, the size of the leaves and the leaf yield.

In a study by Das and Krishnaswamy (1965) indigenous, exotic varieties and species were used as the twelve parents in seven crosses. Inter-specific crosses occured readily. Seed setting in different crosses compared well with that of open pollination and hybrid seeds germinated well. Hybrid vigour appeared especially in *M. indica* X *M. latifolia*, (Kosen) and *M. multicalis* X *M. alba* (Black cherry). F_1 progeny showed great viability and both parental influence on leaf shape was observed. Plants, combining good leaf characters with a capacity of early rooting as cuttings were isolated.

Shablovskayami and Kafian (1967) made crosses of gruziya (Georgia) X Tibilnishz. and isolated hybrids that supressed Gruziya in yield and nutritive quality of the leaves.

Five seed parents belonging to different species and their hybrids, when pollinated by three pollinators, gave heavier seeds, when grown on their own roots on the local small leaved mulberry, the difference varying from 1.6 to 22.0 per cent according to the parental combination. The proportion of seedling with entire leaves was higher in the former. None of the seedlings resembled polymorphic local mulberry variety Husaik, whereas 21.5 per cent of hybrids from grafts did so. The hybrids of the former group were 15 to 38 per cent taller in the early stages at the end of the season. Leaf yield of about 30.0 q per hectare was produced from seedlings at the age of two and a half years (Rahmanberdyev, 1968).

Mulberry breeders in Romania since 1950, have succeeded in produccng new hybrids which combine longevity, vigour, hardiness and early foliage appearance of local variety or varieties with yield and high leaf moisture and protein content of improved varieties (Craiciu, 1969).

Murakami (1973) studied some F_1 progenies which showed low individual variation and a few undesirable plants. Further varietal crosses were made and each resultant F_1 popultion was evaluated for combining ability, inheritance of characters and food value for silk worm. Four of the populations were selected for further work. He also developed a technique production of F_1 seeds under natural conditions and early harvesting from dense planting.

Hidan et al. (1978) selected Minamisakari from F_1 progeny of Kairyoichinose and Kokusa-21. Crossed in 1964 the hybrid was released as Kuwanorin-4 in 1976. The hybrid released has ten superior characters than its parental varieties particularly to its cold resistence.

Fonseca (1978) in a study compared eleven mulberry hybrids with that of variety Calabresa and three crops of leaf yield at three months interval. Leaf yield was more susceptible than leaf dimensions to environmental influences. Hybrids number 13/6 and 19/13 were the most productive. Interactions between genotype and date of pruning affected yield, indicating that selection based on short term assessment of yield may be avoided.

Hybrids between Bulgarian and foreign varieties were studied upto nine to ten years of age. Six crosses gave high percentage of trees with entire leaves. Five hybrids were most useful, having vigorus growth, cold resistence having medium sized to large entire or palmate leaves and a leaf yield of 8250 to 9173 kg/ha (Penkovi, 1979).

Kuchkarov (1981) reported from his study that almost hundred per cent of the hybrid progeny from crosses between inbred lines in 1978-79 consisted of entire leaved and large leaved forms. Leaf yield exceeded the control by 17.05 to 34.75 q/ha in spring and 20.0 to 29.5 q/ha in summer. Thus judicious selection of parental pairs it was posible to obtain phenotypically homgeneous heterotic hybrids.

Hidan et al. (1982) reported, Hayatesakari a new mulberry cultivar bred at the Kyushu branch station of SES, Veki, Kumamoto, Japan by selecting from F_1 plants between Kairyochinose X Kokuso 21. Leaves were four lobed, dark green, lusturous and thick. The hybrid exhibited late hardening in autumn, good sprouting of buds and early sprouting than Shin-Ichinosa. It possessed high leaf yield with thick leaves, highly resistent to bacterial blight. It was also good for chawki rearing.

Dandin et al. (1983) studied 161 accessions comprising 60 germplasm strains and 101 elite artificial or synthesized F_1 plants for ten yield components, namely nature of the leaves, growth rate, internodal distance, fresh weight of 100 leaves, percentage of consumable portion of leaves, sprouting behaviour (%), rooting capacity (%), root prolifertion rate by length and weight, moisture content and moisture retaining ability. Depending upon the nature of the character, suitable evaluation methods were developed and applied for the study. For all the characters studied range of variability, average variation and frequency of maximum variables were studied. Effect of environmental/edaphic factors on the expression of characters is also discussed in brief. Accession showing higher values with respect to each characters were isolated. S_1, RFS-135 and English black showed higher values for **six** characters.

Susheelamma et al. (1990) reported that among the hybrids studied, K-2 X Kokuso 13, Assambola X Philippine and Sujanpur X Kokuso 13 showed higher chlorophyll content while Assambola X Philippines, Kanva-2 X Kosen and English Black X Kosen showed higher ratio of chlorophyll a/b.

2.4.2. Heterosis in other related crops

In a study of 280 F_1 and F_2 hybrids of tobacco, heterosis for yield and agronomic characters was found in 26 hybrids. Larger number of leaves occured in the F_1, number of leaves reduced in succeding generations. A comparitive study of eight F_1 hybrids, equal in yield or nearly equal to the F_1 in seven F_3 plants. Yield was equivalent to that of F_2 when tobacco varieties were hybridised. Resistence to powdery mildew and tobacco mosaic was dominent in line 24. Heterosis for growth and number of leaves over several generations was recorded (Kosmodenjanskij, 1966).

Prasannasimma Rao and Sriramamurthy (1967) reported positive heterosis in several hybrids of tobacco. Among the hybrid combinations involving n/35 as female parent HPI-4 and HPI-11 showed good heterobeltiosis.

Eight interspecific hybrids of Nicotiana tobaccum and two Nicotiana rustica varieties (T_{238} and T_{18}) were observed for number, length and breadth of leaves per plant from the middle regions of the plant. The crosses Suti X Jatti and Moruai X T_{17} gave higher yields than their parents (Jos and Singh, 1968).

Burk and Chaplin (1969) studied agronomic characteristics in tobacco which might facilitate mechanical harvesting in a morphologically diverse group of introductions and their F_1 hybrids, and the group was compared with flue-cured varieties, Hicks and 402. Considerable variation in morphological features was noted among the introductions and hybrid vigour was evident in most of the hybrids. A dominent yellow phenotype which was early and could reduce the number of prunings in harvesting was noticed in several introductions. Compared with their parents, hybrids were intermediate in content of total alkaloids, reducing sugars and α-amino nitrogen.

In a three year study of tobacco hybrids from top crosses involving nine varieties (3 as testers), hybrids with a high degree of heterosis for yield components were found, one of which (line 202-1A X Rila $_{544}$)was judged especially promising for the Dupritsa region of Bulgaria. Heterosis was mainly associated with over dominance effects (Stankev, 1985).

Bhagyalakshmi et al. (1985) estimated heterosis in 41 crosses, between seven commercial varieties of sugarcane used as lines and six Indo-American clones used as testers. Many crosses showed heterosis for stalk yield and stalk weight. Hybrid CO-1336 X IA-3014 was the best combination having highest heterosis for stalk length (39.09%), stalk weight (24.62%) and stalk yield (113.55%) when compred with better parents, heterosis was among low other traits.

Verma (1990) found high heterobeltiosis for quantitative and quality characters, except sucrose content in juice and purity coefficient. Heterosis for stalk weight ranged from -21.32 to 69.6 per cent over better parent and from -11.82 to 57.8 per cent over standard variety, viz., CO-7314 X CO-775, CO-7314 X CO-1148, POJ-2878 X CO-775 and Q_{68} X CO-775, because these combinations produced 14 genotypes showing maximum superiority for stalk weight (51.8%) and for sucrose content (24.4%) respectively over the standard variety.

2.5 Chemical composition of leaves

Variation was observed for protein and carbohydrate content among various open pollinated mulberry hybrids (Salman et al., 1963). Abdullaev et al. (1966) analysed the protein and sugar content in ten promising strains of mulberry and observed varietal differences.

Plaksina and Dzafarov (1968) reported higher protein content in tetraploid mulberry compared to deploid varieties.

In seventeen varieties studied at CSR&TI, Mysore wide range of variation in moisture content was noticed in both tender (61.5% to 75.52%) and coarse leaves (53.54% to 65.72%). Protein content ranged from 14.91 to 20.24 per cent and total mineral content from 13 to 18.33 per cent. Similar observations were recorded in a study with 40 accessions from the germplasm and in selected strains of open pollinated stalk of Kanva-1 (Anon., 1968).

Vasuki and Basavanna (1969) observed varietal differences in content of total mineral in 48 genotypes of mulberry. Mustafaev (1970) reported that diploid varieties of mulberry contained higher amount of protein, nitrogen and carbohydrates.

Wide range of variation was noticed for moisture content in tender (61.58% to 74.12%), medium (8.48% to 70.35%) and coarse (53.36% to 69.0%) leaves. Similar observations were recorded for crude protein content (14.05%

to 33.25%), total mineral content (12.52% to 18.78%) and total sugar content (6.86% to 14.71%) in various genotypes of mulberry studied at CSR&TI, Mysore (Anon., 1970).

Das and Prasad (1974) observed distinctly higher protein, total sugars and total mineral content in triploid varieties compared to tetraploid and diploid varieties with higher or equal moisture content and equal or less fibre content. Dzhafarov and Alekperova (1978) reported that triploids contained higher amount of protein followed by tetraploids and diploids.

Anon., (1975) and Rangaswamy et al. (1978) reported the existence of varietal difference regarding moisture content, crude protein, total minerals and total sugars in mulberry leaves.

Gupta (1977) reported that protein content ranged from 13.8 to 29.4 per cent, 16.96 to 24.48 per cent and 13.86 to 21.28 per cent in diploid, triploid and tetraploid genotypes of mulberry respectively. Pillai et al. (1980) reported 10.95 per cent (Roso) to 23.80 per cent (MR-2) crude protein content in genotypes Roso and MR-2 respectively.

Jolly et al. (1982) observed no significant variation in moisture, total minerals, crude protein and total sugar contents in new strains of mulberry viz., RFS-35, RFS-175, S-21, Kanva-2 and local cultivars.

The moisture content of the leaf fit for young silk worm ranged from 75 per cent (Ber-S_1) to 78 per cent (S_{41}) whereas S_{30} and S_{35} showed 74.0 per cent leaf moisture (Anon., 1983). Maximum moisture content in chawki leaf was recorded in Kosen (77.34%) followed by Ber, C-799 (77.30%) out of 25 varieties except in S_1 where the moisture content was not above 70.0 per cent (Anon., 1983).

Thangamani and Vivekanandhan (1984) observed wide range of variation in eight varieties of mulberry for moisture content (63.67 to 70.60%), total sugars (8.64 to 15.58%), crude protein (21.43 to 29.48%) and total ash (10.35 to 18.90%). The total chlorophyll content was higher in both MR-2 (chlorophyll 'a' = 0.903 mg/g fresh weight and chlorophyll 'b' = 0.488 mg/g fresh weight) and Japanese variety (chlorophyll 'a' = 0.861 mg/g fresh weight and chlorophyll 'b' = 0.473 mg/g fresh weight).

Venkataramu (1986) observed varietal difference for moisture, crude protein, total mineral, crude fibre and total sugar content. Chlorophyll 'a' ranged from 0.654 to 0.772 mg/g fresh weight of leaves, chlorophyll 'b' from 0.381 to 0.414 mg/g fresh weight of leaves and total chlorophyll content from 1.084 mg/g fresh weight to 1.212 mg/g fresh weight of leaves. Wide range of variation regarding for crude protein content, total mineral content and sugar content was observed in different diploids, triploids and tetraploids genotypes studied (Anon., 1987).

Govindan et al. (1988) observed significant differences in moisture content at 8 and 24 hours after harvesting of leaves among six varieties of mulberry.

Sastry et al. (1988) observed significant differences among six genotypes of mulberry for moisture content of leaves at different intervals of harvest. The total chlorophyll content ranged from 1.305 to 2.997 mg/g fresh weight of leaves in the germplasm accessions studied at CSR&TI, Mysore (Anon., 1988).

Bhat (1989) observed significant difference between two genotypes of mulberry for crude fibre content, chlorophyll´a', chlorophyll ´b', total chlorophyll and moisture content at harvest.

Varanagabushan (1990) observed that among the twenty clones studied S_{41}, S_{54}, TR_{10}, Mizusawa, Ber C-776, Jatinuni and Acc. 153 were promising clones based on their fresh leaf yield per plant. Clones TR_{10}, S_{54}, K_2 X BCP_4 and Sujanpur 5 X Kosen 13 possessed high moisture content in the leaves compared to other clones. Among these promising clones, Sujanpur-5 X Kosen 13 possessed higher crude protein content in the leaves.

MATERIAL AND METHODS

III MATERIAL AND METHODS

The material used and methods followed in the course of present investigation, are presented in this chapter.

3.1 Material

The material used in the study comprised of 12 genotypes of mulberry comprising nine hybrids and three checks.

List of genotypes

1. Mizusawa/Cattaneo
2. White Badana/Kosen
3. Sujanpur-1/Philippine S1
4. Sujanpur-1/Philippine S2
5. Local/Kokuso 13 S1
6. Local/Kokuso 13 S2
7. AB/Kokuso 13
8. White Badana/Philippine
9. Mizusawa/Black cherry
10. Mysore Local
11. M5
12. S54

3.2 Environments (Seasons)

The main objective of the study being identification of stable high yielding genotypes suitable for different environment (E), the pruning dates were adjusted to record the observations covering the three seasons of the year. Each pruning was done at 90 days interval so that the crop growth could cover, kharif, rabi and summer.

E_1 - June 1990 to August 1990 (Kharif)

E_2 - October 1990 to December 1990 (Rabi)

E_3 - February 1991 to April 1991 (Summer)

3.3 Methods

3.3.1 Experimental design and layout

The experiment was taken up at Main Research Station, Hebbal, Bangalore. The experiment was laid out in Randomised Complete Block Design (RCBD) with three replications with a spacing of 60 X 60 cm in irrigated pit system. The observations were taken on a established experiment that was three year old garden. For observations, five representative plants in each treatments was selected.

3.4 Cultural practices

Cultural practices like irrigation, fertilizer application, plant protection measures and weeding were attended as per the package of practices for irrigated mulberry. Bottom pruning was carried out in the first week of June, October and February. Observations were recorded at 20th day, 40th day, 60th day and at 90th day. All the characters were studied in three successive crops that covered the three seasons.

3.5 Observations recorded

3.5.1 Yield and yield components

3.5.1.1 Number of leaves per plant

Number of leaves per plant were counted from five labelled plants in each entry likewise total number of leaves were also recorded.

3.5.1.2 Leaf area per plant (cm^2)

Leaf area was estimated by randomly selecting 25 leaves in each harvest. The leaf area was determined in cm^2 by using LI-3100 leaf area meter from LI-COR Inc/LI-COR Limited Nebraska, U.S.A. The oven dry weight of the leaves was recorded in grams and leaf area per plant was calculated using the formulae:

$$LAP = \frac{A \times DM}{DW}$$

where,

LAP = Leaf are per plant (cm^2)

A = Area of 25 leaves (cm^2)

DM = Leaf dry matter yield per plant (g)

DW = Dry weight of 25 leaves (g)

3.5.1.3 Fresh leaf yield per plant (g)

The average leaf yield per plant was estimated from five labelled plants and their weight was recorded. The total fresh leaf yield was recorded in three successive harvests.

3.5.1.4 Total leaf dry matter yield per plant (g)

Average yield of leaf dry matter from five labelled plants was recorded by taking their oven dried weights expressed in grams.

3.5.1.5 Leaf area index (LAI)

Leaf area index was calculated according to the method followed by Watson (1952)

$$LAI = \frac{\text{Total leaf area per plant}}{\text{Land area per plant}}$$

Land area per plant = 60 X 60 cm

3.5.1.6 Plant height (cm)

Height of the shoot was recorded in cm from the base of the plant to the tip of the shoot.

3.5.1.7 Fresh and dry weight of 25 fully developed leaves(g)

Random selection of 25 leaves was done and weight was recorded immediately after harvest and after drying in oven.

3.5.1.8 Internodal distance (cm)

Distance between two nodes was recorded in cm at different canopy levels, viz., top, middle, bottom portion of the main shoot. Average internodal distance was calculated during each harvest.

3.5.1.9 Stomatal frequency on upper and lower surface in each harvest

The semi-solid fluid mix of Xylene and Thermocol was smeared over the leaves and the impression of leaves was observed for stomatal numbers in 10 microscopic fields at 40X.

3.5.1.10 Leaf to stem ratio per plant (by fresh weight)

Leaf to stem ratio was calculated as the proportion of fresh weight of the leaves and stem portion to the total.

3.5.1.11 Number of shoots per plant

Number of primary shoots per plant were counted from five labelled plants under observation.

3.5.2 Chemical composition of leaves, collection of leaf samples

Matured leaves from top eight to fifteenth position were collected from each genotype. Each sample was collected in paper cover and dried under shade for three days. The dried samples were kept in oven at 65 to 70^{o}C for 24 hours to remove excess moisture. The samples were ground to a fine powder using dry leaf grinder. The ground samples were stored in butter paper covers and used for chemical analysis.

3.5.2.1 Chlorophyll content (mg/g fresh weight)

Top fifth and sixth leaves were collected from five labelled plants for estimation of chlorophyll content. Fresh leaf (0.1 g) was taken in a test tube with six ml acetone and 4 ml of dimethylsulphoxide. Test tubes were plugged and kept in dark overnight. The chlorophyll´a', chlorophyll b' and total chlorophyll contents were estimated by recording the absorbance in Spectronic-21 at 663 nm and

645 nm by using the following formula (Arnon., 1949).

Total chlorophyll = $(20.2\ D_{645} + 8.02\ D_{663})$ X V/1000 X W

Where,

D_{663} and D_{645} are the absorbance values at respective nanometers.

V = Volume made up (ml)

W = Weight of fresh sample (g)

Chlorophyll ´a' = $(12.7\ D_{663} - 2.69\ D_{645})$ X V/1000 X W

Chlorophyll ´b' = $(22.9\ D_{645} - 4.68\ D_{663})$ X V/1000 X W

Chlorophyll content was expressed in mg/g of fresh weight.

3.5.2.2 Crude protein content (%)

It was estimated by determining the total nitrogen content in one gram of leaf sample by micro Kjeldahl method. The crude protein was calculated by multiplying the per cent nitrogen with 6.25 (A.O.A.C., 1970).

3.5.2.3 Moisture content (%)

The moisture content in leaves at various intervals after harvest viz., immediately after harvest, six hours after harvest, twelve hours after harvest, eighteen hours after harvest and twenty-four hours after havest was estimated by recording the weight of the samples at each duration. The leaves were uniformly spread in a single layer on a polythene sheet. After weighing these samples, their oven dried weight was also recorded. The moisture content was estimated on fresh weight basis (A.O.A.C., 1970) as follows:

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight - Dry weight}}{\text{Fresh weight}} \times 100$$

3.6 Statistical analysis

The statistical analysis of the data on individual character was carried out on the mean values of five randomly selected plants from each of the three replications. Different statistical methods employed for the analysis, are presented below:

3.6.1 Analysis of variance (ANOVA)

The analysis of variance As per Sundararaj et al. (1972) was carried out for different characters in each season separately in order to assess the variability among the genotypes.

Source of variation	Degrees of freedom	Sum of squares	MSS	F-ratio
Replication	(r-1)	RSS	$\frac{RSS}{r-1} = Mr$	$\frac{MR}{me}$
Treatment	(t-1)	VSS	$\frac{VSS}{k-1} = Mv$	$\frac{Mv}{mv}$
Error	(t-1) (r-1)	ESS	$\frac{ESS}{(k-1)(r-1)} = Me$	
Total	(tr-1)			

Where

r = Number of replications

t = Number of genotypes/varieties

The significance was tested by comparing with the table values as given by Yates (1965). Standard error of means (SEM), critical differrence (CD), coefficient of variation (CV) were worked out using appropriate formula for comparing varietal means.

3.6.2 Two way analysis of variance

The data obtained on fourteen characters from 24 genotypes over three environments were subjected to two way analysis of variance as per Sundararaj et al., (1972). This was done for each character to find out the difference among the genotypes, environments and to reveal the existence of genotype X environemnt interactions, if any. Only after ascertaining the existence of significant genotype X environment (GE) interaction in two way analysis of variance, the data was further subjected to stability analysis.

Algebraic form of the two way analysis of variance as given by Sundararaj *et al*. (1972) is outlined below:

Source of variation	Degrees of freedom	Sum of squares	MSS	Cal. F
Between rows	(r-1)	SSQR	SSQ.R / r-1	MSSR / MSSE
Between columns	(c-1)	SSQC	SSQC / c-1	MSSC / MSSE
Interaction (RXC)	(r-1((c-1)	SSQRxC	SSQRxC / (r-1) (c-1)	MSSRxC / MSSE
Error	rc (n-1)	SSQE	SSQE / rc (n-1)	
Total	(rcn-1)	SSQ T		

3.6.3 Analysis of variance for stability

The analysis of variance for stability as per Eberhart and Russell (1966) model is algebraically represented below:

Source of variation	Degrees of freedom	Sum of squares	MSS	F ratio
Total	(nv-1)	$E_i\ E_j\ Y^2_{.ij}$ - CF		
(a) Varieties(v)	(v-1)	$1/n\ E_i\ Y^2_{.i}$ -CF	MS_1	MS_1/MS_3.
(b) Environments (env)+(vxenv)	v(n-1)	$E_i\ E_j\ Y^2_{.ij} - EY^2_{.i}/n$		
Env. (linear)	1(a)	$1/v\ (E_j\ Y_j\ I_j)^2/E_j\ I^2_{.j}$.		
V x Env linear	(v-1) (b)	$E_i\ [(E_j\ Y_{ij}\ I_j)^2/E_j\ I^2_{.j}]$ - Env (linear) SS	MS_2	MS_2/MS_3.
Pooled deviation	V(n-2)(c)	$E_i\ E_j\ S^2\ I_j$	MS_3.	
Variety-1	(n-2)	$[E_j\ Y^2_{.ij} - (Y_{i.})^2/n] - (E_j\ Y_{ij}\ I_j)^2/E_j\ I^2_{.j}$		
. . .	. . .			
Variety-v	(n-2)	$[E_j\ Y^2_{.vj} - (Y_{v.})^2/n] - (E_j\ Y_{vj}\ I_j)^2/E_j\ I^2_{.j} = E_j\ S^2_{.vj}$.		
Pooled error	n(r-1) (v-1)			

where n= number of environments, v= number of genotypes, r= number of replications, cf = correction factor.

In this model the total sum of squares has been partioned into (a) SS due to genotypes (b) SS due to environments and Genotype X environment (linear) and (c) pooled error. The sum of squares due to environments plus genotype X environment (linear) has been further partioned into (a) SS due to emvironments (linear) (b) SS due to genotype X environment (linear) and (c) pooled deviation. Furthermore the SS due to pooled devaiation has been divided into devaiation from regression due to each genotypes.

3.6.4 Stability analysis

The stability analysis was carried out employing the linear regression model suggested by Eberhart and Russell (1966) and the model is presented below:

$$Y_{ij} = \mu_i + b_i I_j + \sigma_{ij}.$$

where Y_{ij} = The mean of the i^{th} genotype at j^{th} environment. i = (1, 2, 3....... 24. j = 1, 2, 3)

μ_i = The mean of the i^{th} genotype overall the environments

b_i = The regression co-efficient of the i^{th} genotype on the environmental index which measures response of the i^{th} genotype to varying environments.

I_j = The environmental index obtained as the deviation of mean of all the genotypes at the j^{th} environment from the grand mean.

δ_{ij} = Deviation from the regression of the i^{th} genotype at j^{th} environment.

3.6.5 Stability parameters

The mean (μ), the regression coefficient (b_i) and the mean square deviation from linear regression line (S^2d_i) are the three stability parameters proposed by Eberhart and Russell (1966) in their stability model. These parameters were computed using following formulae:

μ_i (mean) = $E_j\ Y_{ij}/n$

b_i (regression coefficient) = $E_j\ Y_{ij}\ I_j/I^2._j$ and

S^2d_i (deviation from the regression coefficient) = $[E_j\ S^2._{ij}/(n-2)]-(S^2e/r)$

where,

n = Number of environments

Y_{ij} = Performance of i^{th} genotype at j^{th} environment

$E_j\ S^2._{ij}$ = Sum of squares of deviations from the regression line

$S^2\ e/r$ = Estimate of pooled error

I_j = Environmental index (i.e., Grand mean - Environmental mean)

3.6.6 'F' and 't' tests

Appropriate 'F' and 't' tests were used as per the model illustrated above to find out the significance of various stability parameters viz., mean, regression coefficient and deviation from regression.

(a) In order to test the significance of the difference among variety means the appropriate 'F' is defined as:

$$F = MS_1 / MS_3.$$

(b) To test that the varieties do not differ for their regression on the environmental index and appropriate 't' test is defined as:

$$t = \frac{b_i - 1}{SE(b)} \quad \text{where } SE(b) = \sqrt{\frac{E\ y^2 - (Ey)^2/n - b^2\ E\ (X-\overline{X})^2.}{(n-2)\quad E\ (x - \overline{x})^2.}}$$

where,

y = Yield

X = Environmental index

n = Number of environments

(c) Individual deviation from linear regression is tested as follows:

$$F = [\ (\ E_j\ S^2._{ij})\ /\ (S-2)\ ]\ /\ \text{pooled error}$$

where, S = Number of environments.

3.6.7 Stable genotype

A variety whith unit regression coefficient (b_i =1) and deviation not significantly different from zero ($S^2 d_i=0$) is said to be the stable one.

3.7 Studies on heterosis

3.7.1. Statistical analysis

Analysis of variance

The treatment means of all the characters were used for statistical analysis, CD values at five per cent and one per cent level and coefficient of variance were computed.

3.7.2 Estimation of heterosis

The mean values for various characters were determined over replications and these used for the estimation of heterosis. Heterosis was calculated as the percentage increase or decrease of mean F_1 performance over the check varieties.

$$\text{Standard heterosis or Heterosis percentage over the check variety} = \frac{F_1 - \text{Check variety}}{\text{Check variety}} \times 100$$

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results obtained from the analysis are presented under the following headings:

1. Variability studies
2. Heterosis
3. Performance of genotypes in different environments
4. Genotype X environment interaction
5. Stability analysis

4.1 Variability studies

4.1.1 Yield and yield components

Mean values of the observations on various characters recorded during the three harvests are presented in Table 1. Significant differences between the clones were observed for fresh leaf yield, leaf dry matter, number of leaves, and leaf area per plant during the three harvests. The fresh leaf yield per plant ranged from 75.55 g in White Badana X Kosen to 259.33 g, Local X Kokuso 13 S_1 with overall mean of 202.06 g. Leaf dry matter per plant ranged from 21.86 in White Badana X Kosen to 84.45 g, Local X Kokuso 13 S_1 with an average of 48.37 g. Number of leaves per plant ranged from 92.66 in White Badana X Kosen to 167.88 in Kanva-2 with an overall mean 134.56 number of leaves across genotype. Leaf area per plant ranged from 3892.55 cm^2 in White Badana

Table 1: Mean performance of twelve genotypes for leaf yield and other related traits (Three harvests) in *Morus* spp.

Genotypes	I crop (Kharif)				II crop (Rabi)				III crop (Summer)				Total of three crops			
	Fresh leaf yield per plant (g)	Leaf dry matter per plant (g)	Number of leaves per plant	Leaf area per plant (cm^2)	Fresh leaf yield per plant (g)	Leaf dry matter per plant (g)	Number of leaves per plant	Leaf area per plant (cm^2)	Fresh leaf yield per plant (g)	Leaf dry matter per plant (g)	Number of leaves per plant	Leaf area per plant (cm^2)	Fresh leaf yield per plant (g)	Leaf dry matter per plant (g)	Number of leaves per plant	Leaf area per plant (cm^2)
Mizusawa/Cattaneo	271.55	68.76	125.33	11063.99	203.33	47.16	95.33	7290.93	218.66	48.45	117.66	9847.59	693.54	164.38	338.32	28202.52
White Badana/Kosen	75.55	21.66	92.66	3892.55	85.77	18.74	83.22	3415.53	96.55	30.90	88.77	5949.48	257.87	71.51	264.65	13257.57
Sujanpur 1/Philippine S_1	246.10	58.31	146.44	15631.71	207.21	51.16	98.22	6450.59	220.66	61.90	126.55	14495.08	672.98	171.38	371.21	36577.25
Sujanpur 1/Philippine S_2	226.44	49.84	125.21	8544.31	163.10	52.70	118.38	5495.19	189.22	46.81	144.22	8971.06	578.76	149.36	387.82	23010.57
Local/Kokuso 13 S_1	259.33	84.45	128.55	12097.58	175.77	48.02	128.77	7103.69	243.44	49.96	170.33	12956.70	677.87	182.43	426.52	32157.98
Local/Kokuso 13 S_2	199.55	45.49	154.88	8381.00	153.22	31.13	154.66	6767.16	186.21	59.31	174.33	11002.14	538.98	135.94	483.87	25816.98
AB/Kokuso 13	168.66	37.16	126.88	4218.54	149.44	32.68	116.99	3931.01	216.21	30.47	135.99	5437.58	534.32	100.32	379.54	15253.80
White Badana/Philippine	181.55	40.81	135.55	7761.52	174.33	39.48	103.66	7136.97	203.66	38.07	143.44	8436.91	559.54	117.38	382.54	23335.41
Mizusawa/Black cherry	151.33	32.37	128.99	7932.23	134.98	33.40	98.66	5922.39	152.22	49.67	119.22	7585.27	438.54	115.44	346.88	21439.89
Mysore Local	203.99	40.43	155.55	6429.76	183.77	45.93	131.88	7391.81	190.88	36.39	135.99	7485.23	578.65	122.79	423.43	21306.80
M_5	220.44	44.89	167.88	8134.26	200.99	42.60	128.44	7807.57	214.66	48.29	131.55	7680.44	636.10	135.79	427.87	23622.28
S_{54}	220.21	56.10	126.88	9654.21	172.77	34.41	122.88	5382.20	185.55	50.18	112.77	6474.48	578.52	140.70	362.54	21510.89
Mean	202.06	48.37	134.56	8645.14	167.06	39.78	115.09	6174.58	193.16	45.86	133.37	8860.16	562.14	133.95	382.94	23790.99
SEM	1.213	1.214	0.995	689.39	1.591	2.027	0.992	180.05	1.265	1.180	1.217	412.51	2.483	2.977	1.940	700.13
F value	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	2.37	2.38	1.95	1351.20	3.12	3.97	1.94	352.89	2.47	2.31	2.38	808.51	4.86	5.83	3.80	1372.25
CD at 1%	3.10	3.10	2.53	1764.83	4.07	5.18	2.54	460.92	3.23	3.02	3.11	1056.02	6.35	7.62	4.96	3512.96
CV (%)	1.04	4.34	1.28	13.81	1.65	8.82	1.49	5.05	1.13	4.45	1.58	8.06	0.76	3.84	0.87	5.09

X Kosen to 15631.71 cm^2 in Sujanpur-1 X Philippine S_1 with an overall mean value of 8645.14 cm^2.

The clones differed significantly for fresh leaf yield per plant, leaf dry matter per plant, number of leaves per plant and leaf area per plant during second harvest. The first leaf yield per plant ranged from 85.77 g (White Badana X Kosen) to 207.21 g (Sujanpur-1 X Philippine S_1) with an average of 167.06 g. Leaf dry matter per plant ranged from 18.74 g (White Badana X Kosen) to 52.79 g (Sujanpur-1 X Philippine S_2) with an average of 39.78 g. Number of leaves per plant ranged from 83.22 (White Badana X Kosen) to 154.66 (Local X Kokuso 13 S_2) with a mean of 115.09 leaves. The leaf area per plant ranged from 3415.53 cm^2 (White Badana X Kosen) to 7807.57 cm^2 (Kanva-2) with an average of 6174.58 cm^2. Significant differences between the clones were noticed for fresh leaf yield per plant, leaf dry matter per plant, number of leaves per plant and leaf area per plant during the third harvest. The fresh yield per plant ranged from 96.55 g (White Badana X Kosen) to 243.44 g (Local X Kokuso 13 S_1) with an average of 193.16 g. The leaf dry matter per plant ranged from 30.90 g (White Badana X Kosen) to 61.90 g (Sujanapur-1 X Philippine S_1) with an overall average of 45.86 g. Number of leaves per plant ranged from 88.77 (White Badana X Kosen) to 174.33 (Local X Kokuso 13 S_1) with an average of 133.37. Leaf area per plant ranged from 5949.48 cm^2 (White Badana X Kosen) to 14495.98 cm^2 (Sujanpur-1 X Philippine S_1) with an average of 8860.16 cm^2.

Total of three harvests on fresh leaf yield per plant, leaf dry matter per plant, number of leaves per plant and leaf area per plant were significantly different among the clones studied. Total fresh leaf yield per plant ranged from 257.87 g (White Badana X Kosen) to 693.54 g (Mizusawa X Cattaneo) with an average of 562.14 g. The total leaf dry matter per plant ranged from 71.51 g (White Badana X Kosen) to 171.38 g (Sujanpur-1 X Philippine S_1) with an overall average of 133.95 g. The total number of leaves per plant ranged from 264.65 (White Badana X Kosen) to 483.87 (Local X Kokuso 13 S_2) with an average of 388.94. The total leaf area per plant ranged from 13257.57 cm^2 (White Badana X Kosen) to 36577.25 cm^2 (Sujanpur-1 X Philippine S_1) with an average of 23790.99 cm^2.

Mizusawa X Cattaneo, Local X Kokuso 13 S_1, Sujanpur-1 X Philippine S_1, Sujanpur-1 X Philippine S_2 and S_{54} showed significantly superior performance over mean for fresh leaf yield per plant among the genotypes studied.

4.2 Heterosis

The results of the experiment conducted to evaluate the

Table 2: Analysis of variance for different characters for nine hybrids and three checks in _Morus_ spp.

	Height of the plant on 20th day	Number of leaves on 20th day	Height of the plant on 40th day	Number of leaves on 40th day	Height of the plant on 60th day	Number of leaves on 60th day	Height of the plant on 90th day	Number of leaves on 90th day	Number of branches	Internodal distance	Fresh weight of 25 leaves	Dry weight of 25 leaves	Fresh weight of stem	Dry weight of stem	Leaf to stem ratio
Treatment m.s.s	17.36	121.03	229.77	314.09	367.26	616.07	1080.86	4810.17	7.07	0.62	501.43	38.90	5931.84	2220.57	0.034
F-Value	1.52	2.13	16.12	8.13	7.77	3.27	4.42	14.39	4.99	301.23	3.18	6.47	2.83	£.45	5.07
at 5%	NS	NS	*	*	*	*	*	*	*	*	*	*	*	*	*
at 1%	NS	NS	**	**	**	**	**	**	**	**	**	**	**	**	**
EMSS	11.40	56.70	14.25	38.61	47.21	188.21	244.36	334.09	1.41	0.02	157.57	6.00	2094.48	366.96	0.006
SEM	1.94	4.34	2.17	3.58	3.96	7.92	9.02	10.55	0.68	0.02	7.24	1.41	26.42	11.05	0.047
CD at 5%	3.82	8.52	4.27	7.03	7.76	15.52	17.68		1.34	0.05	14.20	2.77	51.78	21.67	0.093
CD at 1%	4.99	11.13	4.48	9.18	10.15	20.27	23.10		1.75	0.06	18.55	3.62	67.64	28.31	0.121

(Table 2 Contd....)

	Moisture content of leaves immediately after harvest	Moisture content of leaves 6 hours after harvest	Moisture content of leaves 12 hours after harvest	Moisture content of leaves 18 hours after harvest	Moisture content of leaves 24 hours after harvest	Chlorophyll 'a' content of leaves	Chlorophyll 'b' content of leaves	Total chlorophyll content of leaves	Crude protein content of leaves	Stomatal frequency at lower surface of leaves	Stomatal frequency at upper surface of leaves	Total leaf weight per plant	Leaf area per plant	Leaf area index	Total leaf dry matter per plant
Treatment m.s.s	9.74	15.77	36.49	42.52	39.30	0.02	0.03	0.07	8.55	1.61	1.28	4810.17	15061807.00	1.03	324.26
F-Value	1.32	1.07	1.31	1.60	1.17	2.71	2.16	3.11	4.93	9.10	7.50	14.39	5.76	5.20	4.07
at 5%	NS	NS	NS	NS	NS	*	*	*	*	*	*	*	*	*	*
at 1%	NS	NS	NS	NS	NS			**	**	**	**	**	**	**	**
EMSS	7.33	14.65	27.75	26.54	33.50	0.007	0.016	0.023	1.73	0.176	0.170	334.09	2614120.75	0.198	79.56
SEM	1.56	2.21	3.04	2.97	3.34	0.050	0.073	0.087	0.76	0.242	0.234	10.55	933.47	0.256	5.15
CD at 5%	3.06	4.33	5.96	5.82	6.55	0.098	0.143	0.171	1.48	0.470	0.460	20.68	1829.60	0.500	10.09
CD at 1%	4.00	5.65	7.78	7.61	8.55	0.128	0.187	0.224	1.94	0.620	0.610	27.01	2389.69	0.650	13.18

hybrids and to estimate heterosis percentage over check variety are presented under the following headings:

1. Evaluation of experimental hybrids for yield and
2. Magnitude of heterosis

4.2.1 Evaluation of experimental hybrids

The ANOVA showing mean sum of squares for the chracters plant height, and number of leaves are presented in Table-2. The mean sum of squares for treatments were significant at one per cent level for all the characters except for plant height, number of leaves and moisture content of leaves 20 days after pruning.

4.2.2 Magnitude of heterosis

Heterosis was studied for different characters by comparing the mean values of F_1 with check varieties M_5 and S_{54}. Heterosis was calculated for the following characters viz., plant height, number of leaves, number of branches, internodal distance, fresh weight and dry weight of 25 leaves, fresh weight and dry weight of stem, leaf to stem ratio, moisture percentage of leaves, chlorophyll content of leaves, crude protein content of leaves, stomatal frequency of leaves, total leaf weight per plant, leaf area per plant and total leaf dry matter per plant for nine hybrids and these are presented in Tables 3, 4, 5, 6 and 7 .

4.2.2.1 Plant height

Of the nine hybrids studied, Sujanpur-l/Philippine S_2 and Local/Kokuso 13 S_2 and white Badana/Philippine showed positive standard heterosis over M_5 among which one hybrid manifested significant positive standard heterosis. Standard heterosis percentage ranged from -29.58 to 5.25 at 20th day after pruning. Hybrids Sujanpur-l/Philippine S_2, Local/Kokuso 13 S_2 and Mizusawa/Black chery showed positive heterosis on 40th, 60th and 90th day after pruning. On the 90th day after pruning, hybrids Mizusawa/Cattaneo, White Badana/Kosen, Sujanpur-l/Philippine, Sujanpur-l/Philippine S_2, Local/Kokuso 13 S_1, AB/Kokuso 13, White Badana /Philippine and Mizusawa/Black chery showed positive standard heterosis. Hybrids Mizusawa/Cattaneo, Local/Kokuso 13 S_1, Local/Kokuso 13 S_2, AB/Kokuso 13 and White Badana/Philippine manifested significant positive standard heterosis. Standard heterosis percentage ranged from -10.53 to 17.45.

All the hybrids except Mizusawa/Cattaneo and White Badana/Kosen showed positive heterosis over S_{54}. Hybrids Sujanpur-l/Philippine S_1, Sujanpur-l/Philippine S_2 and Mizusawa/Black chery showed significant positive heterosis on 20th day after pruning. Standard heterosis percentage ranged from -1.862 to 40.02. Sujanpur-l/Philippine S_2, Mizusawa/Black cherry showed significant positive standard heterosis on 40th, 60th, and 90th day after pruning. Hybrids Mizusawa/Cateneo, White Badana/Kosen, Local/Kokuso 13 S_1, Local/Kokuso 13 S_2 and AB/Kokuso 13 showed significant positive standard heterosis on 90th day after pruning. Standard heterosis percentage ranged from -1.13 to 29.80.

4.2.2.2 Number of leaves

All the hybrids showed negative heterosis on 20th and 40th day after pruning for this trait over M_5. While, Sujanpur-1/Philippine S_1 showed positive heterosis, Local/Kokuso 13 S_2 showed significant positive standard heterosis on 60th day after pruning. The percentage of standard heterosis ranged from -37.64 to 26.50. 90th day after pruning Local/Kokuso 13 S_2 and AB/Kokuso 13 showed positive standard heterosis. Particularly Local/Kokuso 13 S_2 showed significant standard positive heterosis.

Standard heterosis calculated using S_{54} as check reveals that, all the hybrids at 20th and 40th day after pruning showed negative heterosis but on 60th day after pruning Sujanpur-1/Philippine S_2 and Local/Kokuso 13 S_2 showed positive standard heterosis. The latter showed significant standard positive heterosis. Sujanpur-1/ Philippine S_1, Sujanpur-1/Philippine S_2 and White Badana/Philippine showed positive heterosis. Local/Kokuso 13 S_1, Local/Kokuso 13 S_2 and AB/Kokuso 13 on 90th day after pruning showed significant positive standard heterosis. The percentage of standard heterosis ranged from -0.03 to 33.47.

4.2.2.3 Number of branches

All the hybrids showed negative heterosis with respect ot M_5. Mizusawa/Cattaneo, Sujanpur-1/Philippine S_2 showed positive standard heterosis. The percentage of standard heterosis ranged from -41.18 to 12.71.

Two hybrids Mizusawa/Cattaneo and Sujanpur-1/Philippine S_2 showed positive standard heterosis. The percentage of standard heterosis ranged from -41.18 to 12.71 with respect to S_{54}.

4.2.2.4 Internodal distance

All the hybrids showed positive heterosis with M_5 and S_{54} and were significant at both 1 per cent and 5 per cent level of significance. Percentage of standard heterosis ranged from 3.16 to 38.54 (M_5) and 17.32 to 57.51 (S_{54}).

4.2.2.5 Fresh and dry weight of 25 leaves

Hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_2 and Mizusawa/Black cherry showed positive standard heterosis with respect to M_5 as check variety. Mizusawa/Cattaneo, Sujanpur-1/Philippine S_2 and Mizusawa/Black cherry showed positive standard heterosis with respect to S_{54} check variety.

4.2.2.6 Fresh weight of stem

The heterosis percentage ranged from -26.49 to 18.32. Hybrids Local/Kokuso 13 S_1 and AB/Kokuso 13 showed positive standard heterosis and hybrid Local/Kokuso 13 S_1 showed significant positive standard heterosis with respect to M_5. Positive heterosis in all the hybrids except White Badana/Kosen and Local/Kokuso 13 S_1 was observed over S_{54}. **Hybrids Sujanpur-1/Philippine S_1, Local/Kokuso 13 S_1** and Local/Kokuso 13 S_2 showed significant positive heterosis. The percentage standard heterosis ranged from -18.82 to 30.67.

4.2.2.7 Dry weight of stem

All the hybrids except Local/Kokuso 13 S_2 and Mizusawa/Black cherry showed positive standard heterosis over M_5. Hybrids Sujanpur-1/Philippine S_1, Sujanpur-1/Philippine S_2, Local/Kokuso 13 S_1 and AB/Kokuso 13 showed significant positive heterosis. The percentage of standard heterosis ranged from -20.73 to 72.35.

Except for the hybrid Local/Kokuso 13 S_2 other showed positive standard heterosis. Hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_1, Sujanpur-1/Philippine S_2, Local/Kokuso 13 S_1, AB/Kokuso 13 and White Badana/Black cherry showed significant positive standard heterosis over S_{54}. The percentage of standard heterosis ranged from -7.09 to 101.99.

4.2.2.8 Leaf to stem ratio

Hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_1 and Local/Kokuso 13 S_2 showed positive standard heterosis. Hybrid Local/Kokuso 13 S_2 manifested significant positive heterosis. Percentage standard heterosis ranged from -47.51 to 18.03 with respect to M_5 check. Even with S_{54} check Sujanpur-1/Philippine S_1, Local/Kokuso showed positive standard heterosis. Hybrid Local/Kokuso 13 S_2 manifested significant positive heterosis.

4.2.2.9 Moisture percentage in leaves

In the hybrids studied for heterosis using M_5 as check all the hybrids except for White Badana/Kosen, Sujanpur-1/Philippine S_1 and Sujanpur-1/Philippine S_2 showed positive standard heterosis. Standard heterosis percentage ranged from -3.20 to 3.21 when observed immediately after harvest of leaves. Hybrids Mizusawa/Cattaneo, AB/Kokuso 13 and White Badana/Philippine showed positive standard heterosis after six, twelve, eighteen and twenty-four hours of harvest. The percentage of standard heterosis ranged from -19.17 to 7.17 at 24 hours after harvest.

The hybrids Local/Kokuso 13 S_2, AB/Kokuso 13 and White Badana/Philippine showed positive standard heterosis for moisture content in leaves immediately after harvest. The percentage standard heterosis ranged from -5.04 to 1.84. Hybrids Mizusawa/Cattaneo, AB/Kokuso 13 and White Badana/Philippine showed positive standard heterosis after six, twelve, eighteen and twenty four hours of harvest with respect to S_{54} check.

4.2.2.10 Chlorophyll content of leaves

Chlorophyll ´a' content

All the hybrids studied manifested negative heterosis except white Badana/Philippine which exhibited zero heterosis. The percentage of heterosis ranged from -18.79 to 0.000 with respect to M_5 check. Hybrids Sujanpur-1/Philipins S_1, Local/Kokuso 13 S_1 and White Badana/Philippine showed positive standard heterosis while rest of the hybrids showed negative heterosis over S_{54} check.

Chlorophyll ´b' content

Hybrids Local/Kokuso 13 S_1, White Badana/Philippine and Mizusawa/Black cherry showed positive standard heterosis. The per cent standard heterosis ranged from -28.35 to 2.98 over M_5 check.

Hybrids Sujanpur-1/Philippine S_2, Local/Kokuso 13 S_1, Local/Kokuso 13 S_2, AB/Kokuso 13, White Badana/Philipine and Mizusawa/Black cherry showed significant standard positive heterosis over S_{54}. The per cent standard heterosis ranged from 11.62 to 72.09.

Total chlorophyll content

Hybrid White Badana/Philippine showed positive standard heterosis for this trait. The other hybrids showed negative heterosis. The per cent standard heterosis ranged from -15.96 to 4.00 over M_5 check. Heterosis percentage ranged from -0.36 to 12.97 over S_{54} check. All the hybrids except Local/Kokuso 13 S_2 showed positive standard heterosis. Hybrids Local/Kokuso 13 S_1, AB/Kokuso 13 and White Badana/Philipine showed significant positive standard heterosis.

4.2.2.11 Crude protein content of leaves

All the hybrids except Sujanpur-1/Philippine S_1 and AB/Kokuso 13 showed negative heterosis. The per cent standard heterosis ranged from -17.02 to 2.04 with respect to M_5. Negative heterosis was observed in all the hybrids over S_{54} check. The per cent standard heterosis ranged from -30.62 to -5.93.

4.2.2.12 Stomatal frequency at upper surface of the leaves

Significant heterosis over M_5 variety was seen in hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_1, Local/Kokuso 13 S_1 and Mizusawa/Black cherry. The per cent standard heterosis ranged from -35.08 to 115.20. Similar trend was observed with reference to S_{54} check.

4.2.2.13 Stomatal frequency at lower surface of the leaves

All the hybrids except Mizusawa/black cherry showed positive standard heterosis. The hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_1, Sujanpur-1/Philippine S_2, Local/Kokuso 13 S_1, Local/Kokuso 13 S_2 and White Badana/Philippine showed significant positive standard heterosis. The per cent standard heterosis ranged from -18.46 to 126.92 with respect to M_5 check.

Significant positive standard heterosis was observed in the hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_1, Local/Kokuso 13 S_1, Local/Kokuso 13 S_2 were observed over S_{54} check. Hybrids White Badana/Kosen, AB/Kokuso 13 and Mizusawa/Black cherry showed positive standard heterosis. The per cent standard heterosis ranged from -35.36 to 79.07.

4.2.2.14 Total leaf weight per plant

The hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_1, Local/Kokuso S_1 showed positive standard heterosis. The per cent standard heterosis ranged from -59.45 to 9.03 with respect to M_5. The per cent standard heterosis ranged from 55.40 to 19.95 over S_{54}. Hybrids Mizusawa/Cattaneo, Sujanpur-l/Philippine S_1, Local/Kokuso 13 S_1 exhibited significant positive standard heterosis.

4.2.2.15 Leaf area per plant (cm^2)

Significant positive standard heterosis over M_5 was observed in hybrids Sujanpur-l/philippine S_1 and Local/Kokuso 13 S_1. Hybrids Mizusawa/Cattaneo and Local/Kokuso 13 S_2 manifested positive standard heterosis. Per cent standard heterosis ranged from -43.87 to 54.84. The hybrids Mizusawa/Cattaneo, Sujanpur-l/Philippine S_1, Local/Kokuso 13 S_1 and Local/Kokuso 13 S_2 showed significant positive standard heterosis. Sujanpur-l/Philippine S_2, White Badana/Philippine showed positive standard heterosis. The per cent standard heterosis ranged from -38.36 to 70.04 with respect to S_{54} check.

4.2.2.16 Leaf area index

Two hybrids viz., Sujanpur-l/Philippine S_1 and Local/Kokuso 13 S_1 manifested significant positive standard heterosis. Hybrids Mizusawa/Cattaneo, Sujanpur-l/Philippine S_2 and Local/Kokuso 13 S_2 exhibited positive standard heterosis and per cent standard heterosis ranged from -43.62 to

21.07 over M_5. Significant positive standard heterosis was observed in hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_1 and Local/Kokuso 13 S_1. The hybrids Sujanpur-1/Philippine S_2, Local/Kokuso 13 S_2 and White Badana/Philippine showed positive standard heterosis. Per cent standard heterosis ranged from -38.82 to 73.40 over S_{54} check.

4.2.2.17 Total leaf dry matter per plant

The hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S_2 and Local/Philippine S_2 manifested positive standard heterosis. The hybrids Sujanpur-1/Philippine S_1 and Local/Kokuso 13 S_1 exhibited significant positive standard heterosis over M_5. The per cent standard heterosis ranged from -47.34 to 34.35.

Positive standard heterosis over S_{54} was observed in hybrids Mizusawa/Cattaneo and Sujanpur-1/Philippine S_2. The hybrids White Badana/Kosen, Sujanpur-1/Philippine S_2 and Local/Kokuso 13 S_1 showed significant positive standard heterosis. The per cent standard heterosis ranged from -28.72 to 49.17.

4.3.1 Performance of genotypes in different environments

The data obtained from nine hybrids and three checks of mulberry for each of the 21 characters were analysed indi-

Table 3: Heterosis per cent for various traits in nine hybrids of Morus spp. over M_5 and S_{54} checks

Hybrids	M_5								S_{54}							
	Plant height on 20th day	Number of leaves on 20th day	Plant height on 40th day	Number of leaves on 40th day	Plant height on 60th day	Number of leaves on 60th day	Plant height on 90th day	Number of leaves on 90th day	Plant height on 20th day	Number of leaves on 20th day	Plant height on 40th day	Number of leaves on 40th day	Plant height on 60th day	Number of leaves on 60th day	Plant height on 90th day	Number of leaves on 90th day
Mizusawa/Cattaneo	-26.23*	-10.77	-27.19**	-17.67**	13.79	-4.59	13.53**	-20.45**	-1.86	-16.52	49.50**	-9.96	25.23**	-6.09	25.46**	-0.034
White Badana/Kosen	-29.58**	-54.74**	-20.60**	-51.89**	-23.53**	-37.64**	8.52	-33.16**	-6.32	-57.66**	-6.67	-47.35**	-15.58**	-38.62**	19.92**	-27.00**
Sujanpur 1/PhilippineS_1	-11.74	-6.01	11.89**	-20.40**	-8.43	-7.11	6.08	-13.26*	17.41	-12.07	31.51**	-12.89*	1.07	-8.50	17.23**	2.39
Sujanpur 1/PhilippineS_2	3.13**	4.00	22.67**	-6.76	4.69	4.62	8.05	-9.38	37.40**	-2.70	44.43**	-8.69	15.57**	2.97	19.40**	6.97
Local/Kokuso 13 S_1	-10.96	-15.10	6.29	-26.52**	-10.05*	-4.31	11.95*	-2.07	18.45	-20.40*	24.93**	-11.96*	-0.71	-5.82	23.66**	17.96
Local/Kokuso 13 S_2	0.33	-6.20	-0.67	-16.50**	-7.25	26.50**	-10.53*	13.05*	33.48*	-14.12	16.14**	-8.69	2.37	24.51**	-1.13	33.47
AB/Kokuso 13	-16.49	-16.46	-4.02	-19.55**	-11.90**	-1.70	-5.59	2.35	11.08	-21.85*	12.81**	-12.64*	-2.75	-3.24	4.32	18.47
White Badana/Philippine	-1.39	-16.51	31.36**	-17.53**	8.59	-1.47	13.22**	-12.59	31.17*	-21.89*	54.40**	-9.75	19.87**	-2.39	25.13	5.55
Mizusawa/Black cherry	5.25	-22.47*	38.98**	-23.36**	14.95**	-16.85*	17.45**	-15.95**	40.02*	-27.47**	63.32**	-16.13**	26.89**	-18.16*	29.80**	-4.31
SEM	1.949	4.347	2.179	3.587	3.967	7.920	5.09	9.025	1.949	4.347	2.179	3.587	3.967	7.020	5.097	9.025
CD at 5%	3.82	8.520	4.270	7.030	7.760	15.520	9.99	17.680	3.820	8.520	4.270	7.030	7.760	15.520	9.990	17.680
CD at 1%	4.99	11.130	4.480	9.180	10.150	20.270	13.05	23.100	4.990	11.130	4.480	9.180	10.150	20.270	13.050	23.100

* Significant at 5%

** Significant at 1%

Table 4: Heterosis per cent for various traits in nine *Morus* hybrids over M_5 and S_{54} checks

Hybrids	M_5							S_{54}						
	Number of branches	Inter-nodal distance	Fresh weight of 25 leaves	Dry weight of 25 leaves	Fresh weight of stem	Dry weight of stem	Leaf to stem ratio	Number of branches	Inter-nodal distance	Fresh weight of 25 leaves	Dry weight of 25 leaves	Fresh weight of stem	Dry weight of stem	Leaf to stem ratio
Mizusawa/Cattaneo	-30.53**	38.50**	16.10	26.38**	-3.83	19.50	13.10	2.89	57.51**	14.36	9.30	6.19	40.05**	13.11
White Badana/Kosen	-60.29**	5.74**	-26.07**	-7.99	-22.77**	3.45	-47.51**	-41.18**	20.26**	-27.18**	-20.42**	-14.71	21.24	-47.54**
Sujanpur 1/Philippine S_1	-34.73**	12.64**	-11.05	-1.02	7.10	72.35**	0.54	-3.32	28.10**	-12.29	-14.39*	18.32*	101.99**	0.54
Sujanpur 1/Philippine S_2	-23.90**	25.28**	22.12*	44.35**	-1.12	32.14**	-3.27	12.71	42.48**	20.29*	24.84**	9.19	54.87**	-3.27
Local/Kokuso 13 S_1	-41.71**	6.32**	-11.24	10.63	18.32*	58.69**	-4.91	-12.86	20.91**	-12.57	-4.31	30.67**	85.98**	-4.91
Local/Kokuso 13 S_2	-35.02**	10.91**	-6.07	-3.24	-26.49**	-20.73	18.03*	-3.75	26.14**	-7.48	-16.32*	-18.82*	-7.09	18.03**
AB/Kokusc 13	-52.97**	3.16**	-12.37	-24.69**	8.52	47.56**	-19.67*	-30.34**	17.32**	-13.69	-36.43**	14.33	72.93**	19.67*
White Badana/Philippine	-42.24**	11.20**	-35.57**	-34.61**	-2.56	18.36	-9.83	-14.45	26.47**	-36.54	-43.45**	7.60	38.72**	-9.83
Mizusawa/Black cherry	-39.70**	22.70**	13.98	20.73**	-8.33	-6.31	-26.22*	-10.69	39.54**	12.26	4.41	1.22	9.80	-26.22
SEM	0.687	0.026	7.247	1.414	26.42	11.05	0.047	0.687	0.026	7.247	1.414	26.42	11.05	0.047
CD at 5%	1.340	0.050	14.20	2.770	51.78	21.67	0.093	1.340	0.050	14.200	2.770	51.78	21.67	0.093
CD at 1%	1.750	0.067	18.55	3.620	67.64	28.31	0.121	1.750	0.067	18.550	3.620	67.64	28.31	0.121

* Significant at 5%

** Significant at 1%

Table 5: Heterosis per cent for moisture content of leaves in nine *Morus* hybrids over M_5 and S_{54} checks

Hybrids	M_5					S_{54}				
	Moisture content of leaves immediately after harvest	Moisture content of leaves 6 hours after harvest	Moisture content of leaves 12 hours after harvest	Moisture content of leaves 18 hours after harvest	Moisture content of leaves 24 hours after harvest	Moisture content of leaves immediately after harvest	Moisture content of leaves 6 hours after harvest	Moisture content of leaves 12 hours after harvest	Moisture content of leaves 18 hours after harvest	Moisture content of leaves 24 hours after harvest
Mizusawa/Cattaneo	1.09	5.49	4.46	7.62	7.17	-0.24	4.00	4.85	12.48*	11.95
White Badana/Kosen	-1.91	-1.18	0.34	-8.11	-12.64	-3.21	-2.55	-0.09	-3.96	-8.74
Sujanpur 1/Philippine S_1	-3.20	-2.50	-8.12	-14.52**	-19.12**	-4.48*	-3.88	-8.59	-1.07	-15.56*
Sujanpur 1/Philippine S_2	-3.02	-2.50	-1.18	-2.35	-4.95	-4.30*	-4.49	-8.15	2.06	-0.71
Local/Kokuso 13 S_1	0.24	-0.28	-3.76	1.28	-3.41	-1.07	-1.64	-3.40	7.08	0.89
Local/Kokuso 13 S_2	1.71	1.25	3.21	0.65	-4.27	0.37	-0.12	3.60	5.82	-0.44
AB/Kokuso 13	1.17	2.60	3.15	6.39	3.65	1.27	1.20	3.53	11.20	8.27
White Badana/Philippine	2.62	1.97	1.62	4.21	1.75	1.84	0.54	2.00	8.92	6.29
Mizusawa/Black cherry	3.21	-5.21	-12.74**	-9.47	-9.16	-5.04*	-6.55*	-12.42*	-5.38	-5.10
SEM	1.564	2.210	3.041	2.974	3.342	1.564	2.210	3.041	2.974	3.342
CD at 5%	3.060	4.330	5.960	5.840	6.550	3.060	4.330	5.960	5.820	6.560
CD at 1%	4.000	5.650	7.780	7.610	8.550	4.000	5.650	7.780	7.610	8.550

* Significant at 5%
** Significant at 1%

Table 6: Heterosis per cent for different leaf characters in nine *Morus* hybrids over M_5 and S_{54} checks

Hybrids	M_5						S_{54}					
	Chlorophyll 'a' content of leaves	Chlorophyll 'b' content of leaves	Total chlorophyll content of leaves	Crude protein content of leaves	Stomatal frequency at lower surface of leaves	Stomatal frequency at upper surface of leaves	Chlorophyll 'a' content of leaves	Chlorophyll 'b' content of leaves	Total chlorophyll content of leaves	Crude protein content of leaves	Stomatal frequency at lower surface of leaves	Stomatal frequency at upper surface of leaves
Mizusawa/Cattaneo	-10.73**	-23.88**	-15.00**	-11.92**	80.76**	115.20**	-4.31	18.60	1.08	-18.81**	115.20**	43.29**
White Badana/Kosen	-10.06**	-17.91	-13.63**	-10.39*	10.76	-23.97	-3.59	27.90	2.70	-17.40**	-23.97	-12.19
Sujanpur 1/Philippine S_1	-5.36	-28.35**	-13.18**	2.04	53.07**	87.71	1.42	11.62	3.24	-5.93	87.71**	64.02**
Sujanpur 1/Philippine S_2	-10.06**	-5.97	-9.09*	-24.74	35.38*	-2.92	-5.03	46.51**	8.10	-30.62**	-2.92	7.31
Local/Kokuso 13 S_1	-4.69	2.98	-5.00	-8.60	126.92**	28.65*	2.15	60.46**	12.97**	-15.75**	28.65*	79.87**
Local/Kokuso 13 S_2	-18.79**	-2.98	-15.96**	-22.25**	121.53**	21.05	1.29**	51.16**	-0.36	-28.33**	21.05*	75.60**
AB/Kokuso 13	-6.71*	-1.49	-6.81	1.91	3.00	-35.08*	-0.24	53.48**	10.81*	-6.05	-35.08*	-18.90
White Badana/Philippine	0.00	1.04	4.00	-7.90	53.07**	81.71	7.19*	72.09**	2.10**	-15.10**	18.71	21.34
Mizusawa/Black cherry	-12.08**	1.49	-13.68**	-17.02**	18.46	33.33*	5.75	32.55*	3.24	-23.51**	33.33*	-35.33*
SEM	0.050	0.073	0.087	0.760	0.238	0.242	0.050	0.073	0.087	0.760	0.238	0.242
CD at 5%	0.098	0.143	0.171	1.480	0.460	0.470	0.098	0.143	0.171	1.480	0.460	0.470
CD at 1%	0.128	0.187	0.224	1.940	0.610	0.620	0.128	0.187	0.224	1.940	0.610	0.620

* Significant at 5%
** Significant at 1%

Table 7: Estimation of heterosis over M_5 and S_{54} for yield components in nine hybrids of *Morus* spp.

Hybrids	M_5				S_{54}			
	Total leaf weight per plant	Leaf area per plant	Leaf area index	Total leaf dry matter per plant	Total leaf weight per plant	Leaf area per plant	Leaf area index	Total leaf dry matter per plant
Mizusawa/Cattaneo	9.03	19.38	21.07	20.92	19.95**	31.10*	31.38*	16.71
White Badana/Kosen	-59.45**	-43.87**	-43.62**	-47.34**	-55.40**	-38.36**	-38.82**	49.17**
Sujanpur 1/Philippine S_1	5.95	54.82**	59.80**	26.20*	16.56**	70.04**	73.40**	21.81*
Sujanpur 1/Philippine S_2	-9.06	-2.48	1.47	9.98	0.03	6.97	10.10	6.16
Local/Kokuso 13 S_1	6.65	36.13**	41.17**	34.35**	19.95**	49.49**	53.19**	29.68**
Local/Kokuso 13 S_2	-15.26**	14.93	8.33	0.11	6.78	26.21*	17.55	-3.36
AB/Kokuso 13	-16.00**	42.47**	-34.80**	-26.13*	-7.59	-36.83**	-29.25*	-28.70**
White Badana/Philippine	-12.02*	-1.21	-0.98	-12.88	-3.21	8.48	7.44	-15.90
Mizusawa/Black cherry	-31.06**	-9.23	-8.82	-15.09	-24.15**	-0.32	-1.06	-17.93
SEM	10.55	933.47	0.256	5.15	10.55	933.47	0.256	5.15
CD at 5%	20.68	1829.60	0.500	10.09	20.68	1829.60	0.500	10.09
CD at 1%	27.01	2389.69	0.650	13.18	27.01	2389.69	0.650	13.18

* Significant at 5%

** Significant at 1%

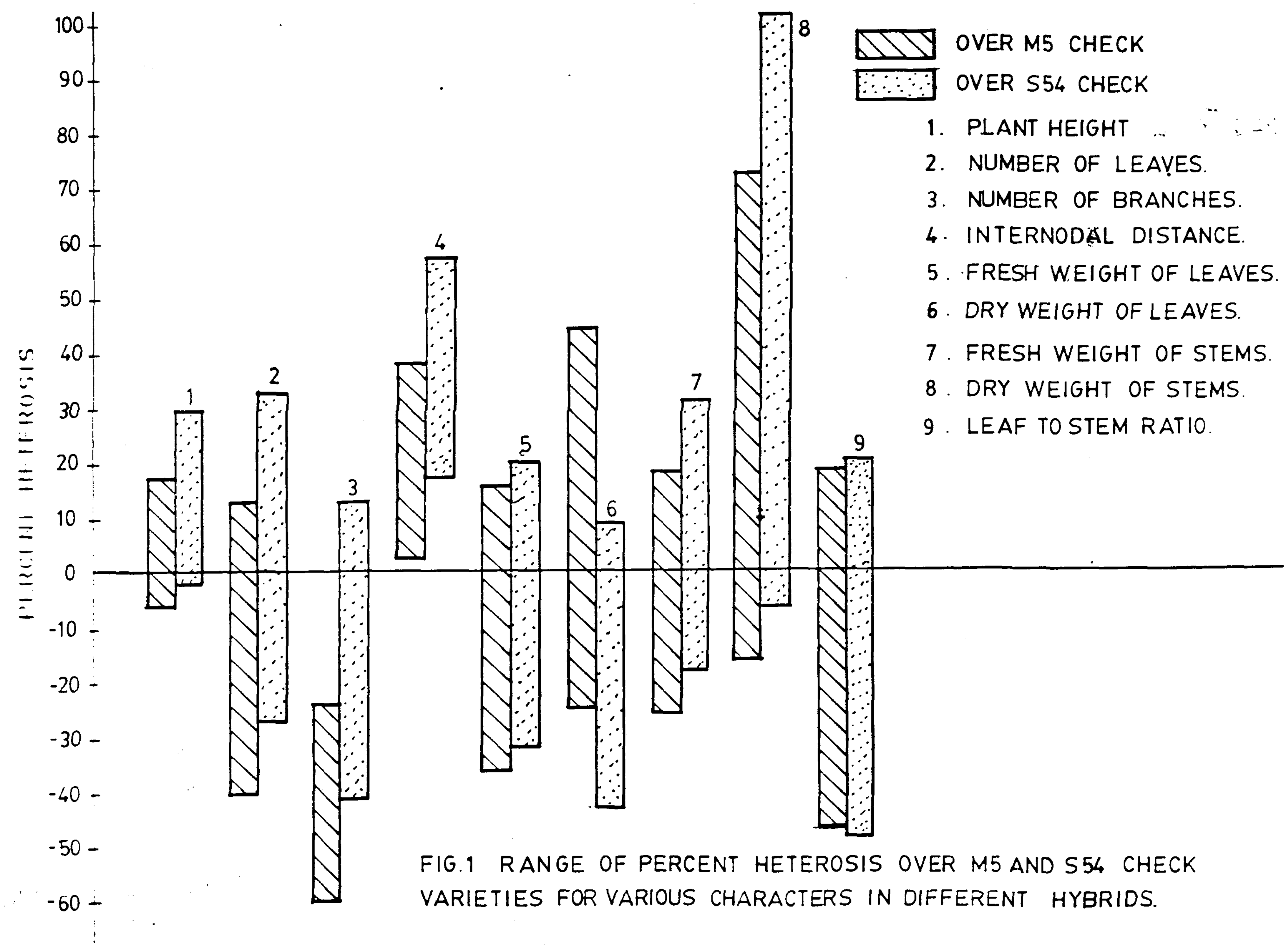

FIG.1 RANGE OF PERCENT HETEROSIS OVER M5 AND S54 CHECK VARIETIES FOR VARIOUS CHARACTERS IN DIFFERENT HYBRIDS.

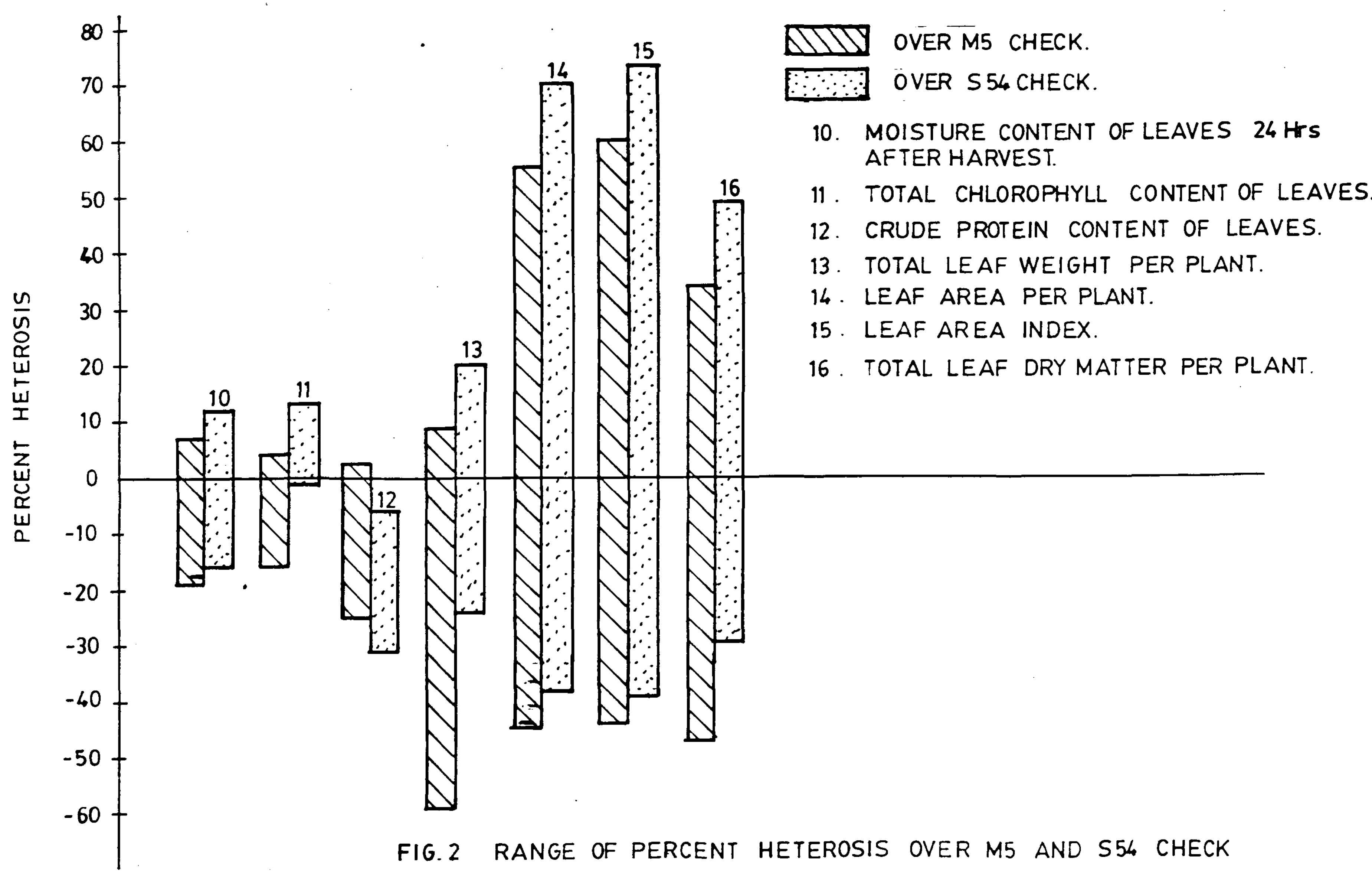

FIG. 2 RANGE OF PERCENT HETEROSIS OVER M5 AND S54 CHECK VARIETIES FOR VARIOUS CHARACTERS IN DIFFERENT HYBRIDS.

vidually to find the performance of genotypes in all the three environments viz., kharif (E_1), rabi (E_2) and summer (E_3). The genotypes were ranked based on their mean values to express their performances (Table 8 to 28).

4.3.1.1 Plant height on 90th day

The plant height differed significantly over environments as indicated by varying environmental indices that ranged from -11.66 to 15.69 and envionmental means ranged between 102.02 to 129.12 cm. Kharif environment (E_1) showed maximum range of variation (61.92 cm) followed by summer (E_3) environment (51.85 cm) and rabi (E_2) environment (29.07 cm). Kharif was found to be more favourable for higher plant height (61.92 cm). Considering the overall means Mysore Local was the tallest (137.45 cm) whereas hybrid Local/Kokuso 13 S_2 was shortest (95.02 cm). Across the environments relative rankings of the genotypes differed significantly and compared to the overall rankings (Table 8).

4.3.1.2 Number of leaves on 90th day

Number of leaves on 90th day of harvest differed significantly from environment to envrionment as indicated by a varying environmental mean and environmental indices (115.09 to 134.56 and -12.36 to 6.44). Summer (E_3) environment

Table 8: Mean values, relative ranking and stability parameters for plant height on 90th day in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	142.09	3	103.45	7	116.17	3	120.57	3	1.40	0.11	1.11
2	White Badana/Kosen	131.53	5	107.05	4	107.19	7	115.26	6	0.97	0.23	26.84**
3	Sujanpur 1/Philippine S_1	127.28	7	97.55	9	113.34	5	112.72	8	1.01	0.30	33.90**
4	Sujanpur 1/Philippine S_2	126.76	8	108.60	3	105.57	8	113.64	7	0.74	0.33	39.91**
5	Local/Kokuso 13 S_1	136.94	4	111.01	2	108.58	6	118.84	5	1.04	0.39	57.31**
6	Local/Kokuso 13 S_2	113.16	10	87.52	12	84.37	12	95.02	12	1.04	0.46	65.32**
7	AB/Kokusa 13	118.34	9	87.77	11	94.69	11	100.27	10	1.13	0.11	0.40
8	White Badana/Philippine	130.80	6	105.72	5	124.25	2	120.25	4	0.80	0.22	81.91**
9	Mizusawa/Black cherry	157.56	2	102.17	8	114.51	4	124.75	2	2.05	0.20	4.87
10	Mysore Local	159.55	1	116.59	1	136.22	1	137.45	1	1.49	0.91	35.81**
11	M_5	107.78	11	105.42	6	105.43	9	106.21	9	0.09	0.31	-0.94
12	S_{54}	97.63	12	88.23	10	102.44	10	96.10	11	0.22	0.20	82.75**
	Mean	129.12		102.02		109.40						
	SEM	1.18		1.11		1.03						
	CD at 5%	2.31		2.15		2.01						
	Range	61.92		29.07		51.85						
	E.I	15.69		-11.66		-4.02						

** Significant different from zero at p=0.01 (7.88) showed maximum range of variation (85.56) followed by kharif (E_1) environment (75.22) and rabi (E_2) environment (71.44). Considering the environmental mean and environmental indices kharif environment was found to be more favourable for number of leaves (134.56) followed by summer environment (133.37) and rabi environment (71.44). Considering the overall means of the genotypes Local/Kokuso 13 S_1 was found to possess maximum number of leaves whereas hybrid White Badana/Kosen was found to possess minimum number of leaves. It is interesting to note that relative rankings of a genotypes for this character varied across the environments when compared to overall rankings (Table 9).

4.3.1.3 Total leaf weight per plant

The maximum range of variation with respect to this character was observed in summer (E_3) (146.98) while it was minimum in kharif (E_1) environment (124.22). Similarly, when environmental indices were considered kharif environment was found to be favourable for the expression of this character with a maximum environmental index of 13.97, while the summer environment proved the other way with environmental index of -19.08. Considering the overall means of the genotypes the genotype Sujanpur-1/Philippine S_1 was found to have maximum leaf weight per plant (232.66 g) while the hybrid White Badana/Kosen had minimum leaf weight per plant (85.51 g). Across the environments the relative rankings of

Table 9: Mean values, relative ranking and stability parameters for number of leaves on 90th day in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	125.33	9	95.33	11	117.66	9	112.77	11	1.40	0.39	16.80*
2	White Badana/Kosen	92.66	12	83.22	12	88.77	12	88.21	12	0.40	0.19	4.65
3	Sujanpur 1/Philippine S_1	146.44	4	98.21	10	126.55	7	123.73	8	2.07	0.91	150.98**
4	Sujanpur 1/Philippine S_2	125.21	10	118.38	6	144.22	2	129.27	5	0.81	0.95	198.93**
5	Local/Kokuso 13 S_1	120.53	11	128.77	3	110.33	11	142.54	3	0.98	2.29	925.07**
6	Local/Kokuso 13 S_2	154.88	3	154.66	1	174.33	1	161.29	1	0.47	0.94	199.67**
7	AB/Kokusa 13	126.88	8	116.99	7	135.66	5	126.51	7	0.73	0.47	45.57**
8	White Badana/Philippine	135.55	5	103.66	8	143.44	3	127.55	6	1.87	0.61	50.23**
9	Mizusawa/Black cherry	128.99	6	98.66	9	119.22	8	115.62	9	1.36	0.49	32.12**
10	Mysore Local	155.55	2	131.88	2	135.99	4	141.62	4	0.78	0.88	172.79**
11	M_5	167.88	1	128.44	4	131.55	6	142.62	2	1.21	1.65	609.15**
12	S_{54}	126.88	7	122.88	5	112.77	10	120.84	10	-0.12	0.66	100.87**
	Mean	134.56		115.09		133.37						
	SEM	0.99		0.99		1.21						
	CD at 5%	1.94		1.94		2.37						
	Range	75.22		71.44		85.56						
	E.I	6.44		-12.36		5.92						

* Significant different from zero at $p = 0.05$ (4.00)

** Significant different from zero at $p = 0.01$ (7.08)

Table 10: Mean values, relative ranking and stability parameters for total leaf weight per plant in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	271.55	2	203.33	2	218.66	3	231.18	2	1.76	1.13	728.04**
2	White Badana/Kosen	275.55	1	84.44	12	96.55	12	85.51	12	-0.10	0.60	196.96
3	Sujanpur 1/Philippine S_1	246.10	4	231.21	1	220.66	2	232.66	1	0.26	0.70	267.75*
4	Sujanpur 1/Philippine S_2	226.44	5	163.10	8	189.22	8	192.92	5	1.73	0.68	237.38*
5	Local/Kokuso 13 S_1	258.66	3	175.77	5	243.44	1	225.95	3	2.56	0.31	11.10
6	Local/Kokuso 13 S_2	199.54	9	153.22	9	186.21	9	179.65	9	1.39	0.10	-18.16
7	AB/Kokusa 13	168.66	11	149.44	10	216.21	4	178.10	10	1.04	1.73	1707.43**
8	White Badana/Philippine	181.55	10	174.33	6	203.76	6	186.54	8	0.42	0.61	343.62*
9	Mizusawa/Black cherry	151.33	12	134.99	11	152.22	11	146.18	11	0.54	-0.46	-1.54
10	Mysore Local	203.99	8	183.77	4	190.88	7	192.88	6	0.54	-0.42	18.22
11	M_5	220.44	6	200.99	3	214.66	5	212.03	4	0.58	-0.48	-18.50
12	S_{54}	220.21	7	172.77	7	185.55	10	192.84	7	1.24	0.90	281.89*
	Mean	202.06		167.06		193.16						
	SEM	1.21		1.59		1.26						
	CD at 5%	2.37		3.12		2.47						
	Range	124.22		146.77		146.89						
	E.I	13.97		-19.08		5.13						

* Significant different from zero at p = 0.05 (4.00)

** Significant different from zero at p = 0.01 (7.08)

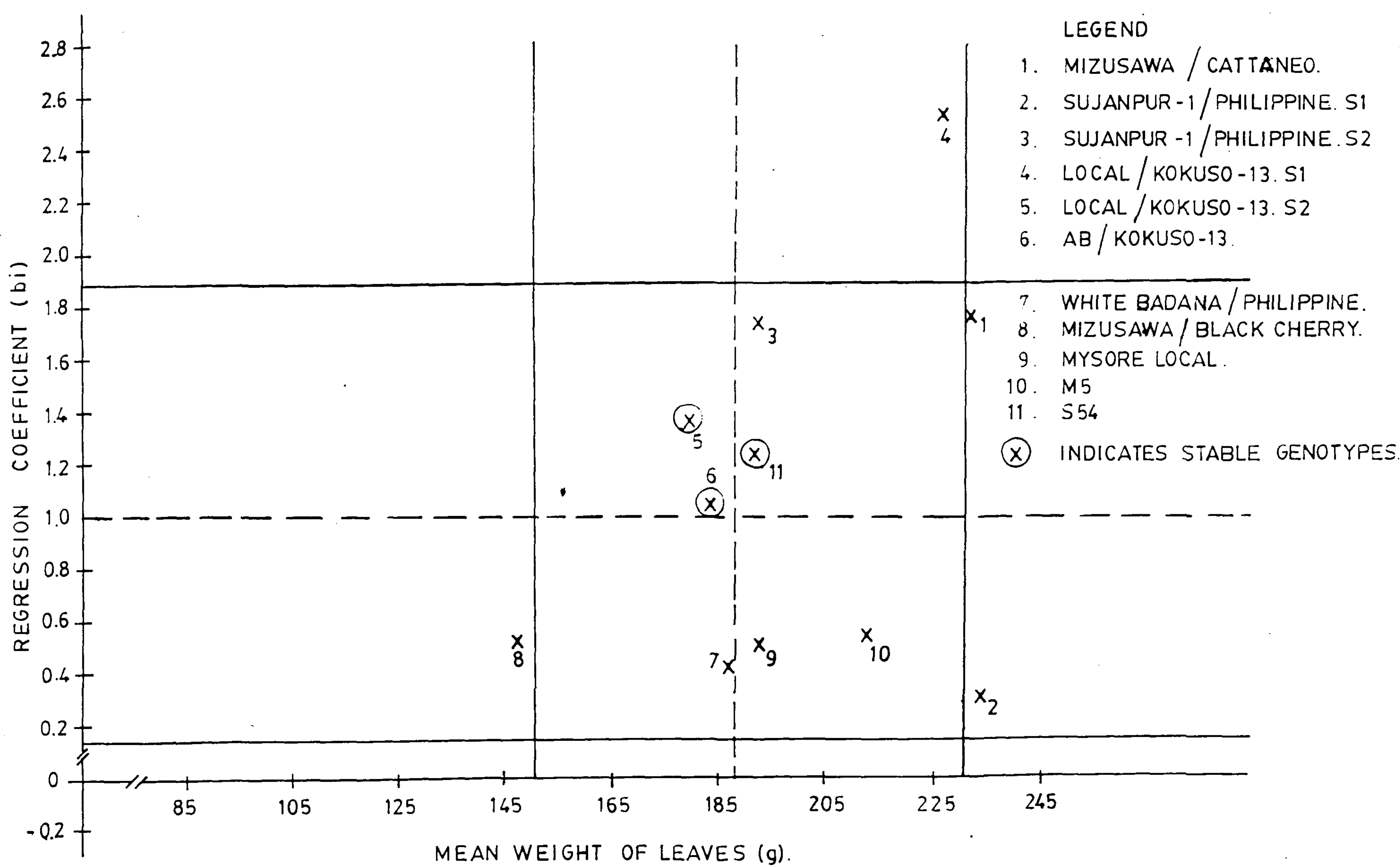

FIG. 3 RELATIONSHIP BETWEEN REGRESSION COEFFICIENT (bi) AND THE MEAN WEIGHT OF LEAVES. (g)

the genotypes differed when compared to the overall rankings (Table 10).

4.3.1.4 Fresh weight of leaves

The environments for fresh weight of 25 leaves differed significantly as indicated by varying environmental indices that ranged from -8.07 to 8.18 and environmental means ranged between 64.89 to 81.07. Kharif (E_1 environment showed maximum range of variation (65.26) followed by summer (E_3) environment (51.09) and rabi (E2) (38.61). Considering the environment mean and environment indices, kharif environment was found to be more favourable for fresh weight of 25 leaves (81.07 g). Considering overall means of the genotypes, the genotype Sujanpur-1/Philippine S_1 was found to have maximum weight (93.55 g). Whereas the genotype White Badana/Philippine showed minimum leaf weight for 25 leaves (49.39 g). Across the environments the relative rankings of the genotypes differed significantly when compared to the overall rankings (Table 11).

3.4.1.5 Dry weight of leaves

The range of variation for this character was maximum in the summer (E_3) environment (15.58) and minimum in the kharif (E_1) environment (12.39). Similarly the environmental means for this character was highest in the kharif (E_1)

Table 11: Mean values, relative ranking and stability parameters for fresh weight of 25 leaves in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	99.96	3	90.23	1	77.63	3	88.97	2	1.31	0.42	1.20
2	White Badana/Kosen	64.70	10	57.28	11	47.93	10	56.63	11	1.03	0.09	-0.88
3	Sujanpur 1/Philippine S_1	78.93	8	78.11	6	47.37	12	68.14	8	1.94	1.06	151.55**
4	Sujanpur 1/Philippine S_2	93.96	4	88.24	2	98.46	1	93.55	1	-0.27	0.68	47.07**
5	Local/Kokuso 13 S_1	66.40	9	70.07	7	67.52	5	67.99	9	-0.07	0.24	4.78
6	Local/Kokuso 13 S_2	100.15	2	62.53	9	53.26	9	71.98	6	2.90	0.96	126.97**
7	AB/Kokusa 13	56.36	11	58.24	10	86.76	2	67.12	10	-1.87	0.94	120.03**
8	White Badana/Philippine	48.70	12	51.62	12	47.86	11	49.39	12	0.04	0.23	5.81
9	Mizusawa/Black cherry	113.96	1	87.75	3	60.24	7	87.32	3	3.32	-0.30	-0.99
10	Mysore Local	84.96	5	67.32	8	57.23	8	69.84	7	1.71	0.24	7.03
11	M_5	83.23	6	79.69	5	66.90	6	76.61	5	1.00	0.34	13.27
12	S_{54}	82.56	7	83.53	4	67.56	4	77.88	4	0.92	0.60	47.19**
	Mean	81.07		72.84		64.89						
	SEM	1.05		1.68		0.99						
	CD at 5%	2.07		3.29		1.91						
	Range	65.26		38.61		51.09						
	E.I	8.18		-0.08		-8.07						

** Significant different from zero at p = 0.01 (7.08)

Table 12: **Mean values, relative ranking and stability parameters for dry weight of 25 leaves in nine crosses and three checks in *Morus* spp.**

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	24.49	1	20.93	3	16.02	5	20.48	2	2.07	0.90	0.13
2	White Badama/Kosen	18.72	8	12.62	11	14.60	6	15.31	10	1.05	1.11	9.58*
3	Sujanpur 1/Philippine S_1	17.45	9	19.29	4	12.69	7	16.48	8	1.11	1.25	12.28**
4	Sujanpur 1/Philippine S_2	23.43	2	24.12	1	24.52	1	24.02	1	-0.26+	0.07	-0.50
5	Local/Kokuso 13 S_1	22.67	4	19.08	5	13.49	8	18.41	5	2.23	0.46	0.65
6	Local/Kokuso 13 S_2	22.82	3	13.76	9	11.73	11	16.10	9	2.76	0.91	5.97*
7	AB/Kokusa 13	12.34	11	12.64	10	12.63	10	12.54	11	-0.07+	0.04	-0.49
8	White Badana/Philippine	12.10	12	11.62	12	8.94	12	10.89	12	0.76	0.31	0.46
9	Mizusawa/Black cherry	20.04	7	21.66	2	18.57	3	20.09	3	0.33	0.68	3.35
10	Mysore Local	20.14	6	16.83	7	13.17	9	16.71	7	1.70	0.23	-0.39
11	M_5	17.08	10	16.87	6	16.30	4	16.75	6	0.18	0.08	-0.48
12	S_{54}	20.83	5	16.56	5	20.63	2	19.34	4	0.09	1.18	11.01**
	Mean	19.31		17.16		15.38						
	SEM	0.83		0.53		0.82						
	CD at 5%	1.63		1.05		1.61						
	Range	12.39		12.50		15.58						
	E.I	2.08		0.005		-1.98						

* Significant different from zero at p = 0.05 (4.00)

** Significant different from zero at p = 0.01 (7.03)

\+ Significant different from one at p = 0.05 (12.70) environment (19.31) and the lowest in the summer (E3) environment (15.38). Kharif environment was found to be more favourable for the expression of this trait with an environmental index of 2.08. While the summer (E3) environment gave a poor environmental index of -1.98. When overall means of the genotypes were considered, the genotype Sujanpur-1/Philippine S_2 was found to give maximum dry weight (24.02 g) and the White Badana/Philippine showed minimum leaf dry weight for 25 leaves. Across the environments the relative rankings of the genotypes for this characters were different when compared with the overall rankings (Table 12).

4.3.1.6 Leaf area per plant

The range of variation for the character was maximum in the kharif (El) environment (11739.16) while it was minimum in the Rabi (E2) environment (4392.04). The environmental mean in the summer (E3) environment was maximum (8860.16) and it was minimum in rabi (E2) environment (6174.58). Similarly when environmental indices were considered kharif (El) environment was more favourable for the expression of this character with a maximum environmental index of 872.21 while the rabi (E_2) environment proved the other way (-1737.23). Considering the means of each genotype over the environments the cross Sujanpur-1/philippine S_1 was found to give maximum leaf area per plant and White Badana/Kosen

Table 13: Mean values, relative ranking and stability parameters for leaf area per plant in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	11063.99	3	7290.13	3	9847.59	4	9400.84	3	1.21	0.41	569910.93
2	White Badana/Kosen	3892.55	12	3415.53	12	5949.48	11	4419.18	12	0.57	0.69	1964777.75**
3	Sujanpur 1/Philippine S_1	15631.71	1	6450.59	7	14495.08	1	12192.46	1	3.30	0.42	459795.43
4	Sujanpur 1/Philippine S_2	8544.31	5	5495.19	9	8971.06	5	7670.19	6	1.25	0.15	-64375.06
5	Local/Kokuso 13 S_1	12097.58	2	7103.69	5	12956.70	2	10719.32	2	2.08	0.29	22609.43
6	Local/Kokuso 13 S_2	8381.00	6	6767.16	6	11002.14	3	8716.77	4	1.12	0.87	3297055.50**
7	[illegible] Kokusa 13	5885.21	11	3931.01	11	5437.58	12	5084.60	11	0.66	0.16	-61227.56
8	White Badana/Philippine	7761.52	9	7136.97	4	7436.91	8	7475.13	7	0.17	0.11	-106986.93
9	Mizusawa/Black cherry	7932.23	8	5922.39	8	7585.27	7	7146.63	9	0.70	0.13	-100838.31
10	Mysore Local	6429.76	10	7391.81	2	7425.23	9	7102.26	10	-0.16	0.35	396496.68
11	[illegible]	8134.26	7	7807.57	1	7680.44	6	7874.09	5	0.03	0.15	-56389.88
12	[illegible]	9654.21	4	5382.70	10	6474.48	10	7170.30	8	1.03	1.03	4872509.00**
	Mean	8645.14		6174.58		8860.16						
	SEm	689.39		180.05		412.51						
	CD at 5%	1351.20		352.89		808.51						
	Range	11739.16		4392.04		9057.50						
	E.I.	872.21		-1737.23		865.02						

** Significant different from zero at p = 0.01 (7.08)

showed minimum leaf area per plant. Across the environments the relative rankings of the genotypes of this character was found different when compared with overall rankings (Table 13).

4.3.1.7 Leaf area index

There was a maximum range of variation for this character in kharif (E1) environment (3.26) while it was minimum in the summer (E3) environment (0.98). However the highest environmental index was in the summer (E3) environment (2.45) and the lowest was in the rabi (E2) environment (1.37). Summer (E3) environment was found to have favourable conditions for the expression of this character as indicated by highest environmental index value of 0.37, whereas the rabi (E2) environment proved to be on the other side with an envronmental index of -0.7. On overall genotypic mean basis, the cross Sujanpur-1/Philipine S_2 was found to give maximum leaf area index folowed by Local/Kokuso 13 S_1 (2.28), Mizusawa/Cattaneo (2.47) but the genotype White Badana/Kosen (1.15) found to show low leaf area index. Most of the genotypes differed very much in their relative rankings across the environments. Except Local/Kokuso 13 S_1 which ranked second in all the environments (Table 14).

Table 14: Mean values, relative ranking and stability parameters for leaf area index in nine crosses and three checks in Morus spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2d_i
1	Mizusawa/Cattaneo	3.07	3	1.61	4	2.73	4	2.47	3	1.19	0.38	0.05
2	White Badana/Kosen	1.07	12	0.75	12	1.64	11	1.15	12	0.57	0.61	0.14*
3	Sujanpur 1/Philippine S_1	4.33	1	1.43	6	4.02	1	3.26	1	2.55	0.53	0.05
4	Sujanpur 1/Philippine S_2	2.37	5	1.37	7	2.48	5	2.07	5	0.98	0.23	-0.004
5	Local/Kokuso 13 S_1	3.35	2	1.70	2	3.59	2	2.88	2	1.65	0.37	0.01
6	Local/Kokuso 13 S_2	2.32	6	1.28	9	3.05	3	2.21	4	1.32	0.62	0.23**
7	AB/Kokusa 13	1.63	11	0.86	11	1.50	12	1.33	11	0.65	0.18	0.00
8	White Badana/Philippine	2.15	9	1.56	5	2.34	6	2.02	7	0.61	0.21	0.005
9	Mizusawa/Black cherry	2.19	8	1.31	8	2.10	7	1.87	9	0.77	0.20	-0.003
10	Mysore Local	1.78	10	1.64	3	2.07	9	1.83	10	0.27	0.21	0.03
11	M_5	2.25	7	1.73	1	2.13	8	2.03	6	0.42	0.16	-0.0002
12	S_{54}	2.67	4	1.19	10	1.79	10	1.88	8	0.96	0.75	0.39**
	Mean	2.43		1.37		2.45						
	SEm	0.11		0.05		0.11						
	CD at 5%	0.21		0.10		0.22						
	Range	3.26		0.98		2.87						
	E.I	2.35		-0.70		0.37						

* Significant different from zero at p = 0.05 (4.00)

** Significant different from zero at p = 0.01 (7.08)

Table 15: Mean values, relative ranking and stability parameters for total leaf dry matter yield per plant in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	68.76	2	47.16	4	48.45	6	54.79	3	2.08	1.78	121.53**
2	White Badana/Kosen	21.86	12	16.74	12	30.96	11	23.83	12	0.66	1.26	60.07**
3	Sujanpur 1/Philippine S_1	58.31	3	51.16	2	61.90	1	57.12	2	1.00	0.72	17.97
4	Sujanpur 1/Philippine S_2	49.84	5	52.70	1	46.81	8	49.78	4	-0.45	0.49	7.11
5	Local/Kokuso 13 S_1	84.45	1	48.02	3	49.96	4	60.81	1	3.50	3.04	356.66**
6	Local/Kokuso 13 S_2	45.49	6	31.13	11	59.29	2	45.30	6	2.22	2.28	201.49**
7	AB/Kokusa 13	37.16	10	32.68	10	30.47	12	33.44	11	0.35	0.68	15.94
8	White Badana/Philippine	40.81	8	39.42	7	38.07	9	39.43	9	0.09	0.29	1.11
9	Mizusawa/Black cherry	32.37	11	33.39	9	49.67	5	38.47	10	0.40	2.16	179.80**
10	Mysore Local	40.43	9	45.93	5	36.42	10	40.93	8	-0.81	0.71	17.50
11	M_5	44.89	7	42.60	6	48.29	7	45.26	7	0.39	0.51	8.11
12	S_{54}	56.10	4	34.41	8	50.18	3	46.90	5	2.53	0.20	-2.21
	Mean	48.37		39.78		45.86						
	SEM	1.21		2.02		1.18						
	CD at 5%	2.38		3.97		2.31						
	Range	62.59		33.96		31.43						
	E.I	3.70		-4.89		1.19						

** Significant different from zero at p = 0.01 (7.08)

4.3.1.8 Total leaf dry matter yield per plant

The environments for total leaf dry matter yield per plant differed significantly as indicated by the environmental means and environmental indices that ranged from 39.78 to 48.37 and -4.89 to 1.19 respectively. The maximum range of variation was observed in kharif (El) environment (62.59) and minimum was in summer (E3) environment (31.43). Considering the environmental means and environmental indices kharif (El) environment was found to be more favourable for higher total leaf dry matter yield per plant (48.37 g). Considering ovrall means of the genotypes, the hybrid Local/Kokuso 13 S_1 have found to produce more leaf dry matter yield per plant and White Badana/Kosen was found to produce lower leaf dry matter per plant. Across the environment the relative rankings of the genotypes differed compared to the overall rankings (Table 15).

4.3.1.9 Moisture content of leaves

Moisture content of leaves immediately after harvest differed significantly from environment to environment as indicated by varying environmental means and environmental indices (95.97 to 77.91 and -0.24 to 023 respectively). Kharif (El) environment showed maximum range of variation (17.36) followed by summer (E3) environment (12.27) and rabi (E2) environment (7.43). Considering the environmental

Table 16: Mean values, relative ranking and stability parameters for moisture content of leaves immediately after harvest in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	62.32	12	76.79	5	77.22	6	72.11	12	-24.38	26.70	64.25
2	White Badana/Kosen	78.58	5	77.96	3	70.53	11	75.69	8	18.10	6.09	-7.75
3	Sujanpur 1/Philippine S_1	74.64	11	75.30	8	73.16	10	74.37	10	3.87	2.61	-8.08
4	Sujanpur 1/Philippine S_2	75.78	9	72.65	11	75.08	8	74.50	9	-0.50	6.98	-3.33
5	Local/Kokuso 13 S_1	78.44	7	72.64	12	79.96	3	77.01	7	-7.43	14.70	14.50
6	Local/Kokuso 13 S_2	78.55	6	77.95	4	77.94	4	78.15	3	1.00	1.08	-8.57
7	AB/Kokusa 13	78.75	4	76.46	6	81.33	1	78.85	2	-7.48	7.20	-3.52
8	White Badana/Philippine	79.51	2	76.36	7	81.01	2	79.29	1	-4.91	23.45	-4.83
9	Mizusawa/Black cherry	77.47	8	75.24	9	69.06	12	73.92	11	17.82	5.25	-8.74
10	Mysore Local	78.98	3	75.00	10	77.36	5	77.11	5	1.02	8.47	-0.78
11	M_5	75.54	10	79.47	2	76.13	7	77.05	6	1.35	35.95	0.05
12	S_{54}	79.68	1	80.07	1	73.82	9	77.86	4	13.75	5.80	-6.80
	Mean	77.91		76.35		75.97						
	SEM	0.50		0.94		1.39						
	CD at 5%	0.98		1.84		2.73						
	Range	17.36		7.43		12.27						
	E.I	0.23		0.03		-0.24						

Table 17: Mean values, relative ranking and stability parameters for moisture content of leaves six hours after harvest in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	73.97	1	72.13	4	73.43	3	73.17	**1**	0.26	0.53	-0.21
2	White Badana/Kosen	72.91	4	72.29	2	60.48	12	68.56	**8**	3.49	2.71	35.14**
3	Sujanpur 1/Philippine S_1	68.92	11	69.77	6	64.55	10	67.65	**9**	1.05	1.37	7.81
4	Sujanpur 1/Philippine S_2	70.79	7	63.75	12	67.10	5	67.21	**10**	1.47	1.66	12.11
5	Local/Kokuso 13 S_1	69.58	10	67.68	7	70.28	4	69.18	**7**	-0.07	0.84	1.94
6	Local/Kokuso 13 S_2	73.16	3	72.28	3	65.97	7	70.47	**4**	2.05	1.38	7.86
7	AB/Kokusa 13	71.36	5	64.33	11	77.88	1	71.19	**2**	-1.35	4.05	81.03**
8	White Badana/Philippine	71.31	6	67.09	9	73.86	2	70.75	**3**	-0.43	2.11	20.81*
9	Mizusawa/Black cherry	69.29	9	67.30	8	60.71	11	65.76	**11**	2.51	1.31	6.95
10	Mysore Local	65.30	12	65.18	10	65.63	9	65.37	**12**	-0.08	0.11	-1.55
11	M_5	69.92	8	72.56	1	65.87	8	69.45	**6**	0.95	1.90	16.51
12	S_{54}	73.65	2	70.86	5	66.60	6	70.37	**5**	2.13	0.69	0.56
	Mean	70.82		68.77		67.64						
	SEM	0.49		1.22		1.79						
	CD at 5%	0.96		2.39		3.50						
	Range	8.67		8.81		17.40						
	E.I	1.73		-0.32		-1.39						

* Significant different from zero at p = 0.05 (4.00)

** Significant different from zero at p = 0.01 (7.08)

means and environmental indices kharif (El) environment was found to be more favourable for moisture content of leaves (77.91) follwed by rabi (E2) and summer (E3) environment (75.97). The overall means of the genotypes was high in White Badana/Philippine (79.29%) whereas cross Mizusawa/Cattaneo showed minimum moisture content (72.11%). Relative rankings of a genotype for this character varied across the environment when compared to overall rankings (Table 16).

The environemnts for moisture content of leaves six hours of harvest differed significantly as indicated by varying enviornmental indices that ranged from -1.39 to 1.73 and environmental means ranged between 67.44 and 70.82. Summer (E3) environment showed maximum range of variation (17.40) followed by rabi (E2) environment (8.81) and kharif (El) environment (8.61). Considering the environmental means and environmental indices kharif (El) environment was found to be more favourable for this character (70.82). Considering the overll means of the genotypes the cross Mizusawa/ Cattaneo was found to have maximum moisture content six hours after harvest (73.17%) and Mysore Local was found to have minimum moisture content. Across the environment, the relative rankings of the genotype differed significantly when compared to the overall rankings (Table 17).

Table 18: Mean values, relative ranking and stability parameters for mositure content of leaves 12 hours after harvest in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	64.22	6	63.72	4	64.74	3	64.22	1	0.05	0.29	-1.87
2	White Badana/Kosen	64.37	4	65.26	2	55.56	8	61.73	5	0.80	3.06	51.35**
3	Sujanpur 1/Philippine S_1	59.06	9	58.96	6	51.70	11	56.78	10	0.85	2.24	28.98*
4	Sujanpur 1/Philippine S_2	62.42	8	57.59	7	62.53	5	60.85	8	1.05	1.29	7.18
5	Local/Kokuso 13 S_1	58.46	12	55.87	8	63.44	4	59.26	9	0.003	2.27	27.28*
6	Local/Kokuso 13 S_2	66.68	1	68.49	1	55.49	9	63.55	2	0.87	4.06	92.31**
7	AB/Kokusa 13	63.52	7	53.16	11	73.87	1	63.51	3	1.10	6.01	204.93**
8	White Badana/Philippine	64.24	5	54.76	9	68.73	2	62.58	4	1.57	3.90	84.95**
9	Mizusawa/Black cherry	55.56	11	53.67	10	50.84	12	53.36	12	0.9	1.02	3.65
10	Mysore Local	57.48	10	51.53	12	56.01	7	55.00	11	1.47	1.08	4.21
11	M_5	65.54	2	63.88	3	55.26	10	61.56	6	1.53	2.87	44.88*
12	S_{54}	65.18	3	61.38	5	57.47	6	61.34	7	1.71	1.50	10.34
	Mean	62.23		59.23		59.64						
	SEM	0.57		1.18		2.31						
	CD at 5%	1.12		2.33		4.53						
	Range	8.22		16.96		23.03						
	E.I	1.93		-1.26		-0.65						

* Significant different from zero at p = 0.05 (4.00)

** Significant different from zero at p = 0.01 (7.08)

The maximum range of variation in respect of moisture content in leaves 12 hours after harvest was observed in the summer (E3) environment (23.03) while the minimum was in kharif (El) environment (8.22) but the environmental mean in kharif (El) environment (62.23) was maximum and it was minimum in the rabi (E2) environment (59.03) simillarly when the environmental indices were considered kharif (El) environment was found to be favourable for the expression of this character with a maxiumum enviromental index of 3.01 while the rabi (E2) environment proved the other way with the minimum environmental index of -1.26. The overall means of the genotypes indicated the cross Mizusawa/Cattaneo found to possess maximum moisture content 12 hours after harvest (64.22%) while the cross Mizusawa/Black cherry showed minimum moisture content (53.36%). Across the environments relative rankings of the genotypes differed when compared to the overll rankings (Table 18).

There was a maximum range of variation for moisture content of leaves 18 hours after harvest in the summer (E3) environment (24.67) while it was minimum in rabi (E2) environment (11.09) . However the highest environmental mean was in the kharif (El) environment (52.53%) and the lowest was in the rabi (E2) environment (48.10%). Kharif (El) environment was found to have the favourable conditions for

Table 19: Mean values, relative ranking and stability parameters for moisture content of leaves 18 hours after harvest in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	55.60	2	54.82	1	58.74	3	56.21	1	0.65	0.52	2.62
2	White Badana/Kosen	53.85	6	45.97	7	44.13	12	47.98	9	0.75	1.95	43.71*
3	Sujanpur 1/Philippine S_1	43.53	12	44.43	11	45.34	9	44.43	12	-0.01	-0.36	-0.95
4	Sujanpur 1/Philippine S_2	53.67	7	47.32	6	51.99	6	50.99	7	1.28	0.30	-1.45
5	Local/Kokuso 13 S_1	53.52	8	49.49	4	57.47	4	53.50	4	1.36	0.87	6.09
6	Local/Kokuso 13 S_2	56.34	1	54.32	2	47.96	8	52.87	5	-0.45	1.71	33.12*
7	AB/Kokusa 13	52.09	9	45.81	8	68.80	1	55.57	2	3.28	3.59	144.68**
8	White Badana/Philippine	54.34	3	44.83	10	64.09	2	54.42	3	3.26	2.14	49.50*
9	Mizusawa/Black cherry	49.52	10	47.83	5	44.47	11	47.27	10	-0.16	1.02	10.26
10	Mysore Local	48.95	11	45.57	9	44.74	10	46.42	11	0.31	0.70	6.09
11	M_5	54.32	4	53.60	3	48.49	7	52.14	6	-0.47	1.19	14.77
12	S_{54}	54.16	5	43.73	12	52.00	5	49.96	8	2.17	0.50	-0.86
	Mean	52.53		48.10		52.35						
	SEM	0.57		1.10		2.13						
	CD at 5%	1.12		3.34		4.17						
	Range	12.81		11.09		24.67						
	E.I	1.50		-2.85		1.35						

* Significant different from zero at p = 0.05 (4.00)

** Significant different from zero at p = 0.01 (7.08)

the expression of this character as indicated by highest environmental index value of 1.50, whereas the rabi (E2) environment proved to be on the other side with an environmental index of -2.85. On overall genotypic mean basis, the cross Mizusawa/Cattaneo was found to have maximum moisture content (56.21%) after 18 hours of harvest and Sujanpur-1/Philippine S_1 possessed minimum moisture content (44.43%). Most of the genotypes differed very much in their relative rankings across the environments (Table 19).

The range of variation for moisture content of leaves 24 hours after harvest was maximum in the summer (E3) environment (28.38) and minimum in the kharif (E1) environment (12.09). Similarly the environmental mean for this character was highest in the summer (E3) environment (46.53) and lowest in the rabi (E2) environment (41.62). Summer (E3) environment was found to be the most ideal environment for the expression of this trait with an environmental index of 2.01, while the third environment gave a poor environmental index of -2.72. When overall means of the genotypes were considered the cross Mizusawa/Cattaneo was found to have maximum moisture content of leaves (50.19%) for 24 hours after harvest and the cross (Sujanpur-1/Philippine S_1 showed minimum moisture content of leaves (38.41%) Across the environments the relative rankings of the genotypes for this character found differed when

Table 20: Mean values, relative ranking and stability parameters for moisture content of leaves 24 hours after harvest in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	49.81	1	48.44	1	52.33	3	50.19	1	0.73	0.33	1.41
2	White Badana/Kosen	45.55	6	36.31	12	40.89	9	40.92	10	1.32	1.35	18.99
3	Sujanpur 1/Philippine S_1	37.72	12	41.12	7	36.40	12	38.41	12	-0.99	-0.55	2.75
4	Sujanpur 1/Philippine S_2	48.27	3	42.51	6	44.66	6	45.14	6	0.70	0.95	8.20
5	Local/Kokuso 13 S_1	44.30	11	42.70	5	48.70	5	45.23	5	1.09	0.64	2.01
6	Local/Kokuso 13 S_2	47.97	4	44.73	3	41.21	8	44.64	8	-0.39	1.32	18.24
7	4B/Kokusa 13	42.69	10	39.82	8	64.78	1	49.09	2	4.34	3.53	143.40**
8	White Badana/Philippine	45.18	8	38.15	9	59.63	2	47.65	3	4.01	2.00	43.53*
9	Mizusawa/Black cherry	45.27	7	44.34	4	38.03	11	42.55	9	-0.99	1.26	16.27
10	Mysore Local	42.85	9	38.51	10	39.21	10	40.19	11	0.37	0.87	6.40
11	M_5	48.38	2	48.33	2	43.90	7	46.87	4	-0.73	0.75	3.94
12	S_{54}	46.39	5	37.99	11	50.11	4	44.83	7	2.54	4.90	-2.63
	Mean	45.36		41.62		46.53						
	SEM	1.03		1.84		2.15						
	CD at 5%	2.03		3.61		4.21						
	Range	12.09		12.13		28.38						
	E.I	0.72		-2.72		2.01						

* Significant different from zero at p = 0.05 (4.00)

** Significant different from zero at p = 0.01 (7.08)

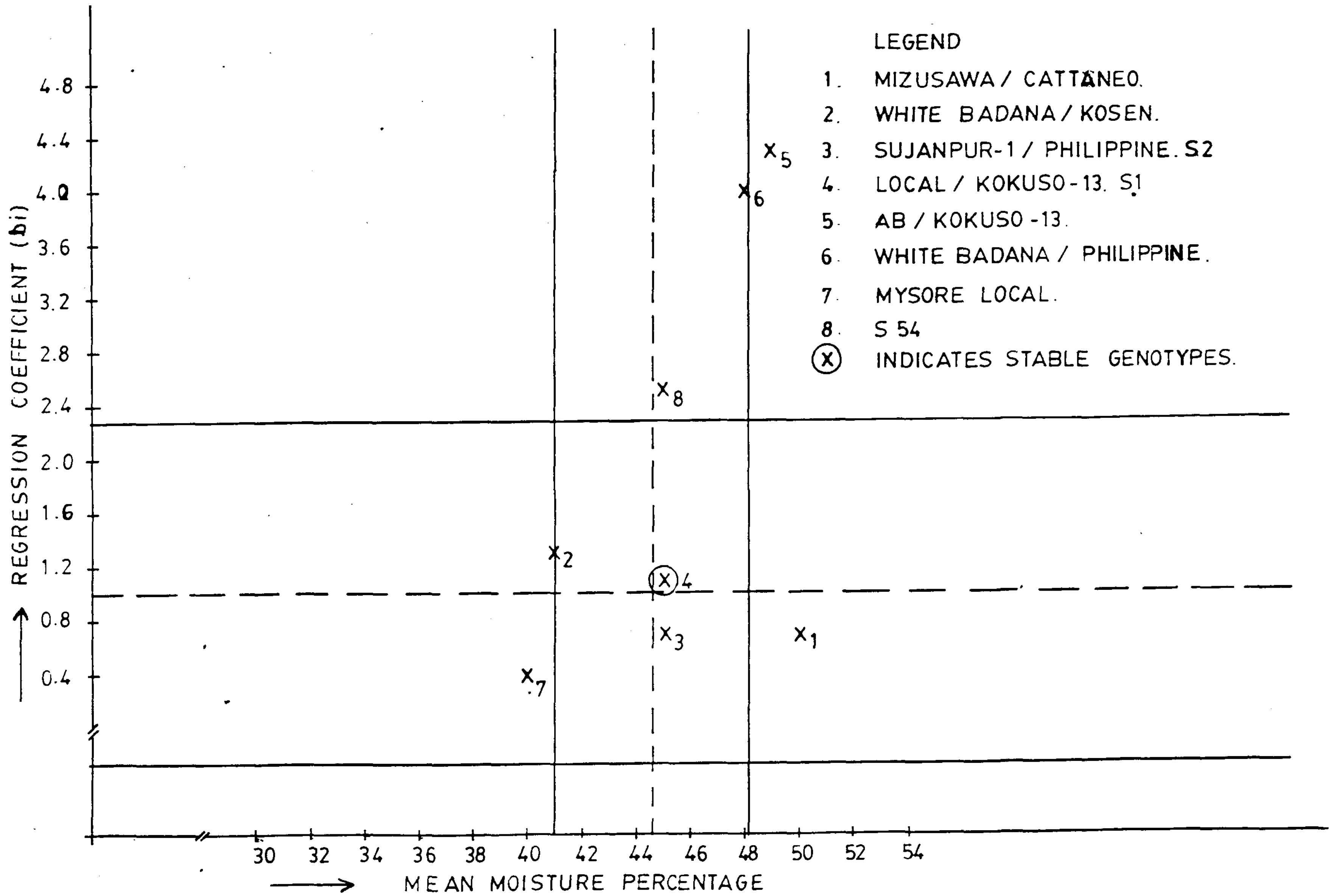

FIG.4 RELATIONSHIP BETWEEN REGRESSION COEFFICIENT (bi) AND THE MOISTURE PERCENTAGE OF LEAVES 24 Hrs AFTER HARVEST.

Table 21: Mean values, relative ranking and stability parameter for leaf to stem ratio by fresh weight in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	0.76	1	0.61	1	0.71	5	0.69	2	0.29	0.77	0.01**
2	White Badana/Kosen	0.23	12	0.33	12	0.42	12	0.33	12	0.84	-0.14	0.006**
3	Sujanpur 1/Philippine S_1	0.54	5	0.58	3	0.72	4	0.61	3	1.07	0.46	0.001**
4	Sujanpur 1/Philippine S_2	0.52	6	0.44	9	0.81	3	0.59	6	2.23	0.70	0.0006**
5	Local/Kokuso 13 S_1	0.44	9	0.49	8	0.83	2	0.59	7	2.46	0.33	0.004**
6	Local/Kokuso 13 S_2	0.64	3	0.61	2	0.91	1	0.72	1	1.93	-0.54	0.000
7	AB/Kokusa 13	0.46	10	0.41	11	0.61	8	0.49	10	1.20	-0.26	0.0002*
8	White Badana/Philippine	0.50	7	0.52	6	0.64	7	0.55	8	0.84	0.81	0.0004*
9	Mizusawa/Black cherry	0.47	8	0.43	10	0.47	11	0.45	11	0.18	-0.17	0.0006**
10	Mysore Local	0.43	11	0.50	7	0.57	10	0.50	9	0.63	0.52	0.003**
11	M_5	0.60	4	0.59	4	0.64	6	0.61	5	0.34	-0.33	0.000
12	S_{54}	0.69	2	0.55	5	0.60	9	0.61	4	-0.05	0.82	0.01**
	Mean	0.52		0.50		0.66						
	SEM	0.003		0.005		0.005						
	CD at 5%	0.007		0.011		0.010						
	Range	0.53		0.28		0.49						
	E.I	-0.04		0.05		0.10						

* Significant different from zero at p=0.05 (4.00)

** Significant different from zero at p=0.01 (7.08) compared to overall rankings (Table 20).

4.3.1.10 Leaf to stem ratio by fresh weight

The environments for leaf to stem ratio by fresh weight differed significantly as indicated by varying environmental indices (-0.04 to 0.10). Kharif (El) environment had the maximum range (0.53) and the mean value was highest in summer (E3) environment (0.66). Considering the overall mean, the cross Local/Kokuso 13 S_2 (0.72) was found to show maximum leaf to stem ratio by fresh weight and it was minimum in the cross White Badana/Kosen (0.33). Across the environments the relative rankings of the genotypes differed when compared to overall rankings (Table 21).

4.3.1.11 Internodal distance

Internodal distance did not differed significantly from environment to environment as indicated by environmental means and environmental indices (3.89 to 3.97 and -0.005 to 0.015). However rabi (E2) environment showed maximum range of variation (1.77) followed by kharif (El) environment (1.75) and summer (E2) environment (1.74). Considering the environmental means and environmental indices kharif (El) environment and summer (E3) environment were found to be more favourable for expression of this character. Considering the overall means the cross Mizusawa/Cattaneo was found to show maximum internodal distance (4.82 cm) and

Table 22: Mean values, relative ranking and stability parameter for internodal distance in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	4.82	1	4.83	1	4.81	1	4.82	1	-0.60	-0.60	-0.0006
2	White Badana/Kosen	3.68	8	3.69	8	3.69	8	3.69	8	-0.39	-0.38	-0.0006
3	Sujanpur 1/Philippine S_1	3.92	5	3.91	5	3.93	5	3.92	5	0.67	-0.66	-0.0006
4	Sujanpur 1/Philippine S_2	4.37	2	4.23	3	4.36	2	4.32	2	6.19	-4.15	-0.0006
5	Local/Kokuso 13 S_1	3.61	9	3.62	9	3.61	9	3.61	10	-0.15	-0.14	-0.0006
6	Local/Kokuso 13 S_2	3.86	7	3.86	7	3.87	6	3.86	7	0.26	-0.25	-0.0005
7	AB/Kokusa 13	3.59	10	3.60	10	3.60	10	3.59	9	-0.25	-0.79	-0.0006
8	White Badana/Philippine	3.87	6	3.87	6	3.87	7	3.87	6	-0.17	-0.16	-0.0005
9	Mizusawa/Black cherry	4.30	3	4.25	2	4.28	3	4.28	3	1.86	4.19	-0.0005
10	Mysore Local	4.12	4	4.11	4	4.12	4	4.12	4	0.31	-0.30	-0.0006
11	M_5	3.54	11	3.46	11	3.53	11	3.51	11	3.66	-3.65	-0.0005
12	S_{54}	3.07	12	3.06	12	3.07	12	3.07	12	0.53	-0.52	-0.0006
	Mean	3.90		3.97		3.89						
	SEM	0.01		0.28		0.02						
	CD at 5%	0.03		0.56		0.04						
	Range	1.75		1.77		1.74						
	E.I	0.01		-0.005		0.01						

Table 23: Mean values, relative ranking and stability parameter for chlorophyll 'a' content of leaves in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	1.30	11	1.32	9	1.39	3	1.33	10	-0.62	-0.62	0.00
2	White Badana/Kosen	1.38	8	1.39	6	1.25	9	1.34	9	0.94	1.05	0.0036*
3	Sujanpur 1/Philippine S_1	1.61	1	1.27	10	1.38	4	1.42	5	1.61	1.84	0.0328**
4	Sujanpur 1/Philippine S_2	1.57	3	1.21	12	1.24	11	1.34	8	2.26	1.70	0.0236**
5	Local/Kokuso 13 S_1	1.55	4	1.47	3	1.25	8	1.42	4	2.04	0.91	0.0027*
6	Local/Kokuso 13 S_2	1.24	12	1.26	11	1.13	12	1.21	12	0.78	0.62	0.0034*
7	AB/Kokusa 13	1.46	7	1.37	7	1.35	7	1.40	7	0.76	0.64	0.0006
8	White Badana/Philippine	1.53	6	1.58	1	1.38	5	1.49	2	1.01	0.98	0.0100**
9	Mizusawa/Black cherry	1.37	9	1.33	8	1.25	10	1.32	11	0.85	-0.85	-0.0001
10	Mysore Local	1.54	5	1.45	4	1.39	2	1.46	3	1.01	-0.14	0.0000
11	M_5	1.58	2	1.55	2	1.36	6	1.50	1	1.49	-0.46	0.0047**
12	S_{54}	1.37	10	1.43	5	1.39	1	1.40	6	-0.16	-0.16	0.0011
	Mean	1.46		1.38		1.31						
	SEM	0.01		0.019		0.015						
	CD at 5%	0.022		0.038		0.030						
	Range	0.37		0.37		0.26						
	E.I	0.072		0.00		-0.072						

*Significant different from zero at p=0.05 (4.00)
**Significant different from zero at p=0.01 (7.08)

check S_{54} showed minimum internodal distance (3.07 cm). It is interesting to note that the relative rankings of a genotype for this character did not varied across the environment when compared to overall rankings (Table 22).

4.3.1.12 Chlorophyll content of leaves

The environment for chlorophyll ´a' content differed significantly as indicated by varying environmental indices ranged from -0.07 to 0.07 and environmental means ranged between 0.26 to 0.37. Kharif (E1) and rabi (E2) environment showed maximum range of variation (0.37) followed by summer (E3) environment (0.26) Considering the environmental means and environmental indices kharif (E1) environment is favourable for chlorophyll ´a' content of leaves (1.46). Considering the overall means of genotypes the check M_5 found to have maximum chlorophyll ´a' content (1.50 mg/g fresh weight) and cross Local/Kokuso 13 S_2 showed minimum chlorophyll content (1.21 mg/g fresh weight). Across the environments the relative rankings of the genotypes differed significantly when compared to overall rankings (Table 23).

The environment for chlorophyll ´b' content differed significantly as indicated by environmental means and environmental indices ranged from 0.54 to 0.70 and -0.073 to 0 082 respectively. The maximum range of variation was observed in the kharif (E1) environment (0.72) and minimum

Table 24: Mean values, relative ranking and stability parameter for chlorophyll 'b' content of leaves in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	0.61	10	0.45	11	0.49	8	0.52	10	0.83	0.36	0.0057*
2	White Badana/Kosen	0.67	7	0.51	10	0.48	9	0.55	9	1.26	0.22	0.0008
3	Sujanpur 1/Philippine S_1	0.33	12	0.55	9	0.58	5	0.49	11	-1.63	-0.44	0.0033
4	Sujanpur 1/Philippine S_2	0.70	4	0.69	3	0.52	7	0.64	7	1.08	0.68	0.0049*
5	Local/Kokuso 13 S_1	0.96	3	0.63	6	0.48	10	0.69	3	3.07	0.64	0.0008
6	Local/Kokuso 13 S_2	0.62	9	0.65	4	0.69	1	0.65	6	-0.46	-0.46	-0.0003
7	AB/Kokusa 13	0.68	5	0.64	5	0.66	2	0.66	5	0.12	-0.12	0.0002
8	White Badana/Philippine	1.05	1	0.59	8	0.59	4	0.74	2	3.06	1.54	0.0228**
9	Mizusawa/Black cherry	0.66	8	0.60	7	0.45	12	0.57	8	1.31	0.86	0.0022
10	Mysore Local	0.99	2	0.78	2	0.62	3	0.80	1	2.34	0.50	-0.0004
11	M_5	0.68	6	0.82	1	0.53	6	0.67	4	0.83	1.60	0.0332**
12	S_{54}	0.48	11	0.42	12	0.46	11	0.45	12	0.14	-0.14	0.0011
	Mean	0.70		0.61		0.54						
	SEM	0.017		0.022		0.019						
	CD at 5%	0.337		0.0044		0.037						
	Range	0.72		0.40		0.24						
	E.I	0.082		-0.008		0.073						

*Significant different from zero at p=0.05 (4.00)
**Significant different from zero at p=0.01 (7.08)

Table 25: Mean values, relative ranking and stability parameter for total chlorophyll content of leaves in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	1.92	10	1.77	12	1.92	6	1.87	10	0.073	0.47	0.0134**
2	White Badana/Kosen	2.05	8	1.91	8	1.73	11	1.90	8	1.04	0.31	0.0012
3	Sujanpur 1/Philippine S_1	1.93	9	1.84	11	1.97	4	1.91	7	-0.09	0.41	0.0071*
4	Sujanpur 1/Philippine S_2	2.28	3	1.96	6	1.77	9	2.00	6	1.72	0.52	-0.0003
5	Local/Kokuso 13 S_1	2.51	5	2.03	4	1.75	10	2.10	4	2.63	0.62	0.0001
6	Local/Kokuso 13 S_2	1.87	11	1.86	9	1.84	8	1.86	11	0.12	0.23	-0.0004
7	AB/Kokusa 13	2.14	6	1.98	5	2.03	1	2.05	5	0.43	0.35	0.0054*
8	White Badana/Philippine	2.58	1	2.17	3	1.98	3	2.24	2	2.07	0.52	0.0012
9	Mizusawa/Black cherry	2.07	7	1.93	7	1.71	12	1.90	9	1.22	0.20	0.0033
10	Mysore Local	2.54	2	2.23	2	2.02	2	2.26	1	1.77	0.39	-0.0004
11	M_5	2.27	4	2.37	1	1.94	5	2.19	3	1.50	0.42	0.0596**
12	S_{54}	1.85	12	1.86	10	1.86	7	1.86	12	-0.036	0.20	-0.0004
	Mean	2.17		1.99		1.88						
	SEM	0.016		0.021		0.019						
	CD at 5%	0.032		0.429		0.037						
	Range	0.73		0.60		0.32						
	E.I	0.15		-0.02		-0.13						

*Significant different from zero at p=0.05 (4.00)

**Significant different from zero at p=0.01 (7.08)

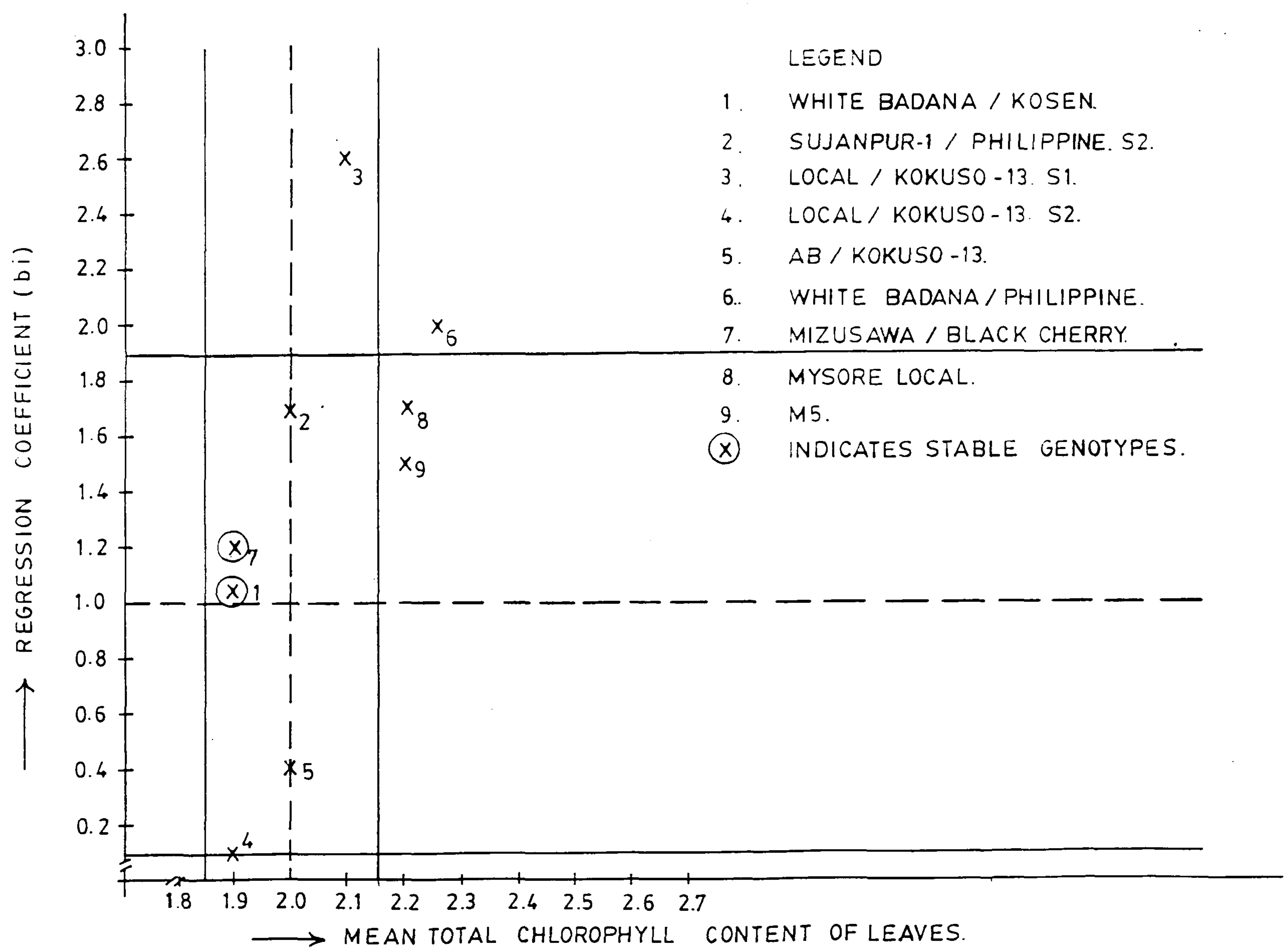

FIG. 5 RELATIONSHIP BETWEEN REGRESSION COEFFICIENT (bi) AND THE MEAN TOTAL CHLOROPHYLL CONTENT OF LEAVES (mg lg FRESH WEIGHT.)

was observed in summer (E3) environment (0.24). Considering the environmental means and environmental indices kharif (El) environment found to be more favourable for chlorophyll 'b' content (0.70). Considering the overall means of the genotypes the check Mysore Local found to have maximum chlorophyll 'b' content and S_{54} found to show minimum chlorophyll b content (0.45 mg/g fresh weight). Across the environment the relative rankings of the genotypes differed compared to the overall rankings (Table 24).

The environment for total chlorophyll contents of the leaves differed significantly as indicated by environmental means and environmental indices ranged from 1.88 to 2.17 and -0.13 to 0.15 respectively. The maximum range of variation was observed in the kharif (El) environment (0.73) and minimum was in the summer (E3) environment (0.32). Considering the environmental means and environmental indices kharif (El) environment was found to be more favourable for chlorophyll content of leaves (2.17). Considering the overall means of the genotypes the check Mysore Local found to possess maximum chlorophyll content (2 26 mg/g fresh weight) and S_{54} found to possess minimum total chlorophyll content (1.86 mg/g fresh weight). Across the environments relative rankings of the genotypes differed compared to the overall rankings (Table 25)

Table 26: Mean values, relative ranking and stability parameter for crude protein content of leaves in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	12.25	3	13.49	8	15.69	7	13.81	8	0.62	0.23	0.640
2	White Badana/Kosen	12.27	2	14.69	6	15.19	9	14.05	7	0.58	0.12	0.076
3	Sujanpur 1/Philippine S_1	10.88	8	16.76	4	20.38	1	16.00	2	1.82	0.13	0.065
4	Sujanpur 1/Philippine S_2	9.07	12	13.29	9	13.05	12	11.80	12	0.83	0.35	1.511**
5	Local/Kokuso 13 S_1	12.24	5	14.84	5	15.93	6	14.33	5	0.72	0.034	-0.053
6	Local/Kokuso 13 S_2	10.26	10	12.10	11	14.21	11	12.19	11	0.73	0.18	0.330
7	AB/Kokusa 13	12.25	4	17.02	3	18.69	3	15.98	3	1.26	0.17	0.081
8	White Badana/Philippine	12.50	1	13.88	7	16.96	5	14.44	6	0.79	0.36	1.560**
9	Mizusawa/Black cherry	10.85	9	13.08	10	15.12	10	13.02	9	0.80	0.14	0.182
10	Mysore Local	10.06	11	11.36	12	15.68	8	12.37	10	0.98	0.54	3.790**
11	M_5	11.49	7	17.61	2	17.96	4	15.69	4	1.32	0.41	2.020**
12	S_{54}	12.17	6	19.48	1	19.39	2	17.01	1	1.50	0.54	3.940**
	Mean	11.36		14.80		16.52						
	SEM	0.219		0.303		0.242						
	CD at 5%	0.429		0.595		0.475						
	Range	3.43		8.12		7.33						
	E.I	-2.86		0.58		2.30						

**Significant different from zero at p=0.01 (7.08)

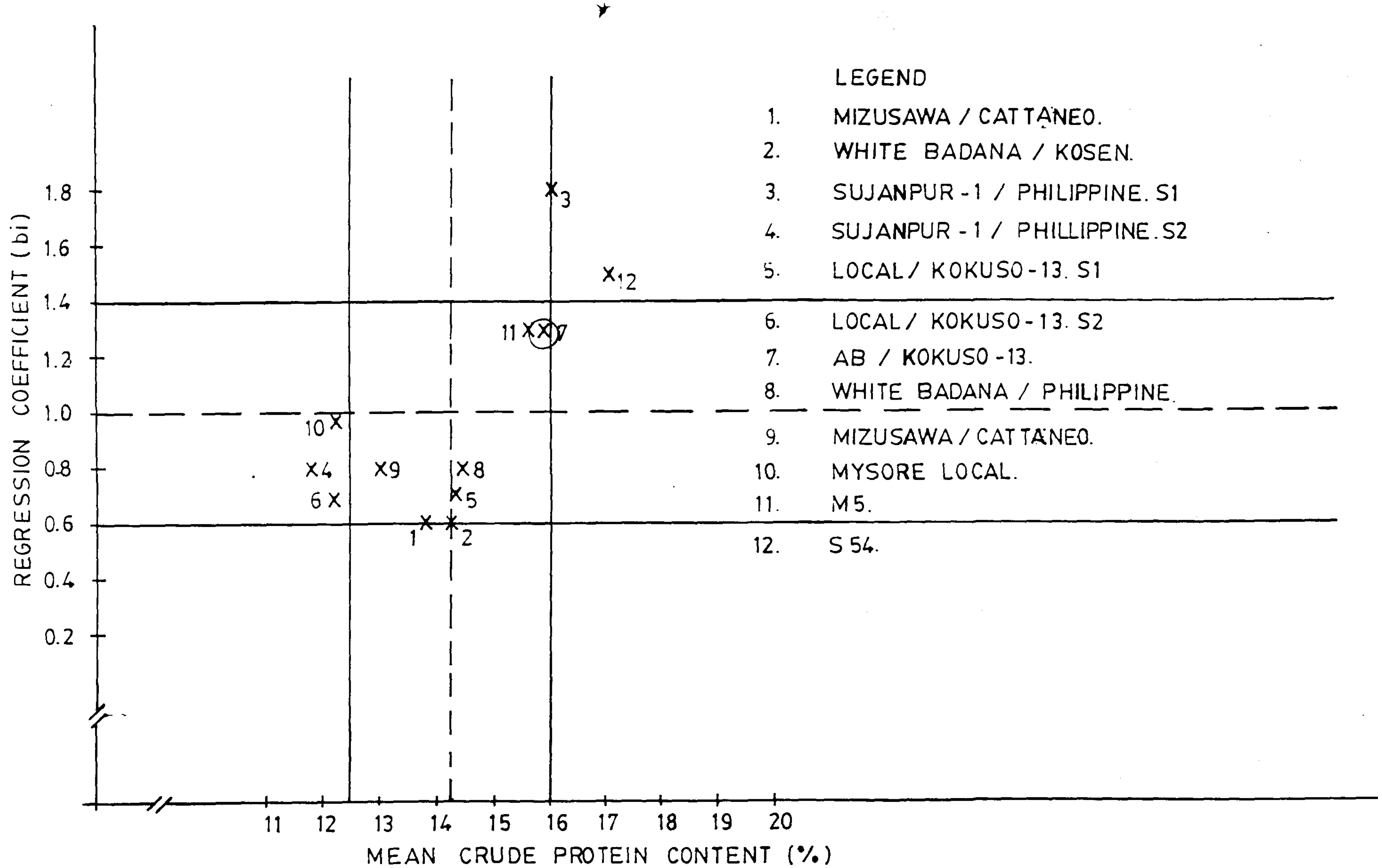

FIG. 6 RELATIONSHIP BETWEEN REGRESSION COEFFICIENT (bi) AND THE MEAN CRUDE PROTEIN CONTENT OF LEAVES. (%)

4.3.1.13 Crude protein content of leaves

The maximum range variation in respect of this character was observed in rabi (E2) environment (8.12) while the minimum was in kharif (E1) environment (3.43), but environmental indices in the summer (E3) environment (16.52) was maximum and it was minimum in the kharif (E1) environment (11.36). Similarly when environmental indices were considered summer (E3) environment was found to be favourable for the expression of this character with maximum environmental indices (7.33), while the kharif (E1) environment proved the other way with minimum environmental indices of (2.86). Considering overall means of the genotypes the check variety S_{54} was found to have maximum crude protein content (17 01%) and cross Sujanpur-1/Philippine S_2 had minimum crude protein content (11.80%). Across the environments the relative rankings of the genotypes differed when compared to the overall rankings (Table 26).

4.3.1.14 Stomatal frequency of the leaves

There was a maximum range of variation for stomatal frequency at lower surface of leaves in the kharif (E1) environment (2 53) while it was minimum in the rabi (E2) environment (1.96). However, the highest environmental means was in kharif (E1) environment (2 38) and the lowest was in the rabi (E2) environment (1.62). Kharif (E1) envi-

Table 27: Mean values, relative ranking and stability parameter for stomatal frequency on lower surface of leaves in nine crosses and three checks in *Morus* spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	$S^2 di$
1	Mizusawa/Cattaneo	4.30	1	2.82	1	3.93	1	3.68	1	1.80	0.40	-0.0117
2	White Badana/Kosen	1.16	12	1.02	11	1.74	9	1.30	11	0.53	0.73	0.1476
3	Sujanpur 1/Philippine S_1	4.12	2	1.68	6	3.84	2	3.21	2	3.16	0.61	-0.0392
4	Sujanpur 1/Philippine S_2	2.83	3	1.19	10	1.96	8	1.99	7	1.72	0.95	0.2485
5	Local/Kokuso 13 S_1	2.46	5	1.51	8	2.65	3	2.21	4	1.41	0.40	-0.0003
6	Local/Kokuso 13 S_2	2.01	8	1.62	7	2.60	4	2.07	5	0.87	0.80	0.1731
7	AB/Kokusa 13	1.29	11	0.86	12	1.19	11	1.11	12	0.53	0.10	-0.0395
8	White Badana/Philippine	2.04	7	1.87	4	2.19	6	2.03	6	0.32	0.11	-0.026
9	Mizusawa/Black cherry	2.58	4	1.91	3	2.45	5	2.31	3	0.83	0.099	-0.0390
10	Mysore Local	1.75	10	2.02	2	2.02	7	1.93	8	-0.21	0.29	-0.0086
11	M_5	1.77	9	1.70	5	1.67	10	1.71	10	0.04	0.091	0.374
12	S_{54}	2.30	6	1.28	9	1.55	12	1.71	9	0.95	0.83	0.1972
	Mean	2.38		1.68		2.31						
	SEM	0.462		0.086		0.165						
	CD at 5%	0.906		0.169		0.324						
	Range	2.53		1.96		2.38						
	E.I	0.28		-0.47		0.21						

Table 28: Mean values, relative ranking and stability parameter for stomatal frequency at upper surface of leaves in nine crosses and three checks in Morus spp.

Sl. No.	Genotypes	E_1 Mean	E_1 Rank	E_2 Mean	E_2 Rank	E_3 Mean	E_3 Rank	Overall Mean	Overall Rank	b_i	SE(b)	S^2di
1	Mizusawa/Cattaneo	2.80	3	1.84	4	2.49	4	2.37	4	1.18	0.39	0.0265
2	White Badana/Kosen	1.29	11	1.13	10	1.92	6	1.45	9	0.68	0.80	0.1823
3	Sujanpur 1/Philippine S_1	3.58	1	1.33	6	3.17	3	2.69	3	2.99	0.68	0.0535
4	Sujanpur 1/Philippine S_2	2.16	6	1.26	7	1.86	7	1.76	6	1.09	0.40	0.0248
5	Local/Kokuso 13 S_1	3.34	2	1.96	2	3.57	2	2.95	1	2.18	0.46	0.0149
6	Local/Kokuso 13 S_2	2.80	4	2.18	1	3.68	1	2.88	2	1.53	1.17	0.3850**
7	AB/Kokusa 13	1.55	8	1.03	11	1.43	10	1.34	10	0.67	-0.14	-0.0113
8	White Badana/Philippines	1.97	7	1.88	3	2.13	5	1.99	5	0.24	0.09	-0.0039
9	Mizusawa/Black cherry	1.27	12	0.88	12	1.04	12	1.06	12	0.41	0.22	0.0067
10	Mysore Local	1.48	9	1.62	5	1.62	8	1.57	8	-0.094	0.45	-0.0085
11	M_5	1.30	10	1.16	9	1.24	11	1.23	11	0.16+	-0.06	-0.0165
12	S_{54}	2.22	5	1.23	8	1.49	9	1.65	7	0.92	0.92	0.2468*
	Mean	2.14		1.45		2.13						
	SEM	0.230		0.106		0.211						
	CD at 5%	0.450		0.209		0.414						
	Range	2.31		1.30		2.64						
	E.I	0.23		-0.45		0.22						

*Significant different from zero at p=0.05 (4.00)

**Significant different from zero at p=0.01 (7.08)

+Significant different from one at p=0.05(12.706) ronment found to have favourable conditions for the expression of this character as indicated by highest environmental index (0.28) whereas rabi (E2) environment proved to be on the otherside with an environmental indices of (-0 47). On overall genotypic mean basis, the cross mizusawa/Cattaneo possessed highest stomatal number (3 68) and AB/Kokuso 13 had the lowest stomatal number (1 11) Most of the genotypes differed very much in their relative rankings across the environments except Mizusawa/Cattaneo which ranked first in all the three environments (Table 27)

The range of variation for stomatal frequency at upper surface of leaves was maximum in the summer (E3) environment (2.64) and minimum in the rabi (E2) environment (1 30), but the environmental means for this character was highest in the kharif (E1) environment (2 14) and the lowest in the rabi (E2) environment (1.45) Kharif (E1) environment was found to be most ideal environment for the expression of this character with environmental indices of 0.23 while the rabi (E2) environment gave a poor environmental indices of -0.45. When overall means of the genotypes were considered the cross Local/Kokuso 13 S_1 found to possess maximum number of stomata (2.95) and Mizusawa/Black cherry possessed minimum number of stomata (1.06). Across the environments the relative rankings of the genotypes for this character found differed when compared to overall rankings (Table 28).

4.3.2 Genotype X Environmental Interaction

The ability of a genotype to produce a narrow range of phenotype in differnent environments can be called as 'stability' Lewis (1954) The statistical procedures used to find out the stability of a genotypes can be termed as "stability analysis".

As per the definition of the stability accroding to Lewis (1954), and in general we may conclude genotypes will be stable in the absence of the environmental infuence as well as genotype X environment ineteraction and vice-versa, thus identification of and confirmation of the presence of environmental influence and genotype X environmental interaction is a pre-requisite for stability analysis.

In the present investigation the magnitude of genotype X environment interaction as well as the influence of environments on genotypes were assessed for each character using the procedure given by Sundararaj et al., 1972 for two way analysis of variance The summary of analysis of variance showing the significant differences of genotypes, environments and genotype X environments along with error components are presented in Table 29 and the same has been discribed in the following paragraphs.

Table 29: Summary of two way analysis of variance for twentyone characters in Mours spp.

Sl. No.	Characters	Mean sum of squares due to Genotypes (11)	Environments (3)	Genotype x environment (22)	Error (66)
1	Plant height on 90th days	463.82**	2392.26**	75.63**	3.63
2	Number of leaves on 90th day	1021.70**	1429.71**	161.16**	3.45
3	Total leaf weight per plant(g)	5010.29**	3514.50**	353.46**	56.11
4	Fresh weight of 25 leaves(g)	501.22**	785.32**	157.92	96.30
5	Dry weight of 25 leaves(g)	37.91**	49.75**	6.33**	1.52
6	Leaf area per plant	13999407.00**	27162112.00**	2652939.75**	477769.69
7	Leaf area index	1.03**	4.60**	0.19**	0.028
8	Total leaf dry matter yield/plant	324.52**	234.35	79.41**	6.96
9	Moisture contnet of leaves immediately after harvest	14.61**	0.74	14.46	26.08
10	Moisture content of leaves six hours after harvest	15.90	30.21	14.42**	4.89
11	Moisture content of leaves twelve hours after harvest	37.55	34.73	27.54**	7.09
12	Moisture content of leaves eighteen hours after harvest	43.33	74.80	26.34**	7.77
13	Moisture content of leaves twentyfour hours after harvest	38.79	72.16	32.83**	8.25
14	Leaf to stem ratio by fresh weight	0.034**	0.086**	0.0067**	0.00073
15	Internodal distance (cm)	0.62**	0.0019	0.0007	0.0018
16	Chlorophyll'a' content	0.02**	0.062**	0.0074**	0.00065
17	Chlorophyll 'b' content	0.032	0.074**	0.015**	0.0011
18	Total chlorophyll content	0.718**	0.2598**	0.022**	0.0012
19	Crude protein content	8.55**	82.90**	1.73**	0.1990
20	Stomatal frequency at lower surface of leaves	1.57**	2.13**	0.19	0.124
21	Stomatal frequency at upper surface of leaves	1.30**	1.87**	0.17**	0.054

** Significant at 0.01 per cent probability

Note:- Figures in parentheses indicates degrees of freedom able 30: Analysis of variance for stability for twentyone characters in nine crosses and three checks of *Morus* spp.

ource of ariance	df	Plant height on 90th day	Number of leaves on 90th day	Total leaf weight per plant (g)	Fresh weight of 25 leaves (g)	Dry weight of 25 Leaves (g)	Leaf area per plant cm^2	Leaf area index	Total leaf dry matter yield per plant	Moisture content of leaves immediately after harvest (%)	Moisture content of leaves 6 hours after harvest (%)	Moisture content of leaves 12 hours after harvest (%)
notypes (G)	11	463.83**	1021.70**	5010.29**	501.22**	37.91**	13999407.00**	1.03**	324.52**	14.61	15.90	37.55
vironment + (GE	24	268.68**	266.87	616.88	210.21**	9.95*	4695370.5**	0.56**	92.32	13.32	15.94	28.14
vironment (Linear	1	4784.39**	2859.49**	7029.18**	1570.67**	99.51**	54323664.0**	9.21**	466.71*	1.43	60.44	69.44
(Linear)	11	110.97**	93.15	345.22	267.06**	8.32	4096427.00*	0.30*	66.74	17.06	9.88	1.75
oled deviation	12	36.94**	210.06**	331.55**	44.73**	3.97**	1108701.37**	0.08**	84.41**	10.89	17.38**	48.89**
oled error	66	3.63	3.45	56.11	4.91	1.52	477769.69	0.02	6.96	26.08	4.89	7.09

* Significant at 5% probability level
** Significant at 1% probability level

(Table 30 contd...)

Source of variance	df	Moisture content of leaves 18 hours after harvest (%)	Moisture content of leaves 24 hours after harvest (%)	Leaf to stem ratio by fresh weight	Internodal distance (cm)	Chlorophyll 'a' content (mg/g)	Chlorophyll 'b' content (mg/g)	Total Chlorophyll content (mg/g)	Crude protein content (%)	Stomatal frequency at lower surface of leaves	Stomatal frequency at upper surface of leaves
Genotypes (G)	11	43.33	38.79	0.03**	0.62**	0.02*	0.03**	0.07**	8.55**	1.57**	1.30**
Environment + (GE)	24	30.37	36.11	0.01*	0.0008**	0.01	0.02*	0.04**	8.4**	0.36**	0.31**
Environment (Linear)	1	149.63*	144.32*	0.17**	0.0038**	0.12**	0.14**	0.51**	165.81**	4.26**	3.74**
GE (Linear	11	21.88	39.56	0.0098*	0.0013**	0.007	0.023**	0.036**	2.10	0.30*	0.24*
Pooled deviation	12	28.22**	23.93**	0.0033**	0.000	0.0071**	0.0066**	0.0079**	1.24**	0.08	0.093
Pooled error	66	7.77	8.25	0.00007	0.0018	0.00065	0.0011	0.0012	0.199	0.12	0.054

* Significant at 5% probability level

** Significant at 1% probability level

Table 31: Suitable genotypes (characterwise) for different environments and overall the environments in *Morus* spp.

Sl. No.	Characters	Genotypes with good performance during: Kharif	Rabi	Summer	Overall stable
1	Plant height on 90th day	Mysore Local	Mysore Local	Myore Local	Mizusawa/Cattaneo
		Mizusawa/Black cherry	Local/Kokuso 13 S_1	White Badana/Philippine	Mizusawa/Black cherry
		Mizusawa/Cattaneo	Sujanpur 1/PhilippineS_2	Mizusawa/Cattaneo	AB/Kokuso
		Local/Kokuso 13 S_1	White Badana/Kosen	Mizusawa/Black cherry	----
2	Number of leaves on 90th day	M_5	Local/Kokuso 13 S_2	Local/Kokuso 13 S_2	----
		Mysore Local	Mysore Local	Sujanpur 1/Philippine S_2	----
		Local/kokuso 13	Local/Kokuso 13 S_1	White Badana/Philippine	----
		Sunjanpur 1/philippine S_1	M_5	Mysore Local	----
3	Total leaf weight per plant	White Badana/Kosen	Sujanpur 1/Philippine S_1	Local/Kokuso 13 S_1	Local/Kokuso 13 S_2 .
		Mizusawa/Cattaneo	Mizusawa/Cattaneo	Sujanpurl /Philippine S_1	----
		Local/Kokuso 13 S_1	M_5	Mizusawa/Cattaneo	----
		Sujanpur 1/PhilippineS_1	Mysore Local	AB/Kokuso	----
4	Fresh weight of 25 leaves	Mizusawa/Black cherry	Mizusawa/Cattaneo	Sujanpur 1/Philippine S_2	Mizusawa/Cattaneo
		Local/Kokuso 13 S_2	Sujanpur 1/PhilippineS_2	AB/Kokuso 13	White Badana/Kokuso
		Mizusawa/Cattaneo	Mizusawa/Black cherry	Mizusawa/Cattaneo	----
		Sujanpur 1/Philippine S_2	S_{54}	S_{54}	----
5	Dry weight of 25 leaves	Mizusawa/Cattaneo	Sujanpur 1/PhilippineS_2	Sujanpur 1/Philippine S_2	Mizusawa/Cattaneo
		Sujanpur 1/PhilippineS_2	Mizusawa/Black cherry	S_{54}	Local/Kokuso 13 S_1.
		Local/Kokuso 13 S_2	Mizusawa/Cattaneo	Mizusawa/Black cherry	Mysore Local
		Local/Kokuso 13 S_1	Sujanpur 1/Philippine S_1	M_5	----
6	Leaf area per plant	Sujanpur 1/Philippine S_1	M_5	Sujanpur 1/Philippine S_1	Sujanpur 1/Philippine S_2.
		Local/Kokuso 13 S_1	Mysore Local	Local /Kokusa 13 S_1	----
		Mizasawa/Catteneo	Mizasawa/Cattaneo	Local/Kokuso 13 S_2	----
		S_{54}	White Badana/Philippine	Mizusawa/Cattaneo	----
7	Leaf area index	Sujanpur 1/Philippine S_1	M_5	Sujanpur 1/Philippine S_1	Mizusawa/Cattaneo
		Local/Kokuso 13 S_1	Local/Kukoso 13 S_1	Local/Kokuso 13 S_1	Sujanpur 1/Philippine S_1.
		Mizusawa/Cattaneo	Mysore Local	Local/Kukosa 13 S_2	Sujanpur 1/Philippine S_2.
		S_{54}	Mizasawa/Catteneo	Mizusawa/Cattaneo	Local/Kokusa 13 S_1.
8	Total leaf dry matter yield per plant	Local/Kokuso 13 S_1	Sujanpur 1/Philippine S_2	Sujanpur 1/Philippine S_1	----
		Mizusawa/Cattaneo	Sujanpur 1/Philippine S_1	Local/Kokuso 13 S_1	----
		Sujanpur 1/Philippine S_1	Local/Kukoso 13 S_1	S_{54}	----
		S_{54}	Mizusawa/Cattaneo	Local/Kuoso 13 S_2	----
9	Moisture content of leaves immediately after harvest	S_{54}	M_5	AB/Kukoso	M_5 .
		White Badana/Black cherry	S_{54}	White Badana/Philippine	S_{54} .
		Mysore Local	White Badana/Kosen	Local/Kokuso 13 S_1	Local/Kokuso 13 S_2.
		AB/Kokuso 13	Local/Kokuso 13 S_2	Local/Kokuso 13 S_2	Sujanpur 1/Philippine S_1.
10	Moisture content of leaves six hours after harvest	Mizusawa/Cattaneo	M_5	AB/Kokuso 13	S_{54}.
		S_{54}	White Badana/Kosen	White Badana/Philippine	----
		Local/Kokuso 13 S_2	Local/Kokuso 13 S_2	Mizusawa/Cattaneo	----
		White Badana/Kosen	Mizusawa/Cattaneo	Local/Kokuso 13 S_1	----

(Table 31 contd....)

Sl. No.	Characters	Genotypes with good performance during: Kharif	Rabi	Summer	Overall stable
11	Moisture content of leaves tweleve hours after harvest	Local/Kokuso 13 S_2 M_5 S_{54} White Badana/Kosen	Local/Kokuso 13 S_2 White Badana/Kosen M_5 Mizusawa/Cattaneo	AB/Kokuso 13 White Badana/Philipine Mizusawa/Cattaneo Local/Kokuso 13 S_1	---- ---- ---- ----
12	Moisture content of leaves eighteen hours after harvest	Local/Kokuso 13 S_2 Mizusawa/Cattaneo White Badana/Philippine M_5	Mizusawa/Cattaneo Local/Kokuso 13 S_2 M_5 Local/Kokuso 13 S_1	AB/Kokuso 13 White Badana/Philippine Mizusawa/Cattaneo Local/Kokuso 13 S_1	Sujanpur 1/Philippine S_2. S_{54}. ---- ----
13	Moisture content of leaves twenty four hours after harvest	Mizusawa/Cattaneo M_5 Sujanpur/Philippine S_2 Local/Kokuso 13 S_2	Mizusawa/Cattaneo M_5 Local/Kokuso 13 S_2 Mizasawa/Balck cherry	AB/Kokuso 13 White Badana/Philippine Mizusawa/Cattaneo S_{54}	S_{54}. ---- ---- ----
14	Leaf to stem ratio by fresh weight	Mizusawa/Cattaneo S_{54} Local/Kokuso 13 S_2 M_5	Mizusawa/Cattaneo Local/Kokuso 13 S_2 Sujanpur 1/Philippine S_1 M_5	Local/Kokuso 13 S_2 Local/Kokuso 13 S_1 Sujanpur 1/Philippine S_2 Sujanpur 1/Philippine S_2	Local/Kokuso 13 S_2. ---- ---- ----
15	Internodal disstance	S_{54} M_5 AB/Kokuso 13 Local/Kokuso 13 S_1	S_{54} M_5 AB/Kokuso 13 Local/Kokuso 13 S_1	S_{54} M_5 Local/Kokuso 13 S_1 AB/Kokuso 13	M_5. Mizusawa/Black cherry Sujanpur 1/Philippine S_2. ----
16	Chlorophyll 'a' content of leaves	Sujanpunr 1/Philippine S_1 M_5 Sujanpur 1/Philippine S_2 Local/Kokuso 13 S_1	White Badana/Philippine M_5 Local/Kokuso 13 S_1 Mysore Local	S_{54} Mysore local Mizusawa/Cattaneo Sujanpur 1/Philippine S_1	Mysore Local Mizusawa/Black cherry ---- ----
17	Chlorophyll 'b' content of leaves	White Badana/Philippine Mysore Local Local/Kokuso 13 S_1 Sujanpur 1/Philippine S_2	M_5 Mysore Local Sujanpur 1/Philippine S_2 Local/Kokuso 13 S_2	Local/Kokuso 13 S_2 AB/Kokuso 13 Mysore Local White Badana/Philippine	White Badana/Kosen Local/Kokuso 13 S_1. Mizusawa/Black cherry Mysore Local
18	Total chlorophyll content of leaves	White Badana/Philippine Mysore local Sujanpur 1/Philippine S_2 M_5	M_5 Mysore Local White Badana/Philippine Local/Kokuso 13 S_1	AB/Kokuso 13 Mysore Local White Badana/Philippine Sujanpur 1/Philippine	White Badana/Kosen Sujanpur 1/Philippine Local/Kokuso 13 S_1. White Badana/Philippi
19	Crude protein content of leaves	White Badana/Philippine White Badana/Kosen Mizusawa/Cattaneo AB/Kokuso 13	S_{54} M_5 AB/Kokuso 13 Sujanpur 1/Philippine S_1	Sunjanpur 1/Philippine S_1 S_{54} AB/Kokuso 13 M_5	AB/Kokuso 13 Sujanpur 1/Philippine ---- ----
20	Stomatal frequency of leaves on lower surface of leaves	White Badana/Kosen AB/Kokuso 13 Mysore Local M_5	AB/Kokuso 13 White Badana/Kosen Sujanpur 1/Philippine S_1 S_{54}	S_{54} AB/Kokuso 13 M_5 White Badana/Kosen	Mizasawa/Catteneo Sujanpur/Philippine S_1 Sujanpur/Philippine Local/Kokuso 13 S_1.
21	Stomatal frequency of leaves on upper surface of leaves	Mizusawa/Black cherry White Badana/Kosen M_5 Mysore Local	Mizusawa/Black cherry AB/Kokuso 13 White Badana/Kosen M_5	Mizusawa/Black cherry M_5 AB/Kokuso 13 S_{54}	Mizusawa/Cattaneo Sujanpur 1/Philippine Sujanpur 1/Philippine Local/Kokuso 13 S_2.

Nine crosses and three checks of mulberry varieties were tested in three environments in a randomised black design with three replications. Following two way analysis of variance the mean sum of squares for 21 characters in three environments were analysed. The results revealed significant differences among genotypes, environments and genotypes X environments at one per cent level of significance for all 21 characters when there means sum of squares tested against error sum of squares.

Since genotype X environment interaction was found to be significant for all the characters in order to know the magnitude of predictable and unpredictable sources of variation towards genotype x environment interaction, further partitioning of their total sums of squares was done employing the procedure of Eberhart and Russell (1966). The results of which have been summarised in Table 30 and same has been described below.

Variance due to genotypes (G) were found significant for all the characters except for moisture content of leaves, when the mean sums of squares (MSS) tested against pooled deviation and variance due to environment + (Genotype X environment) were found significant for all the characters except for number of leaves, total leaf weight per plant, moisture content of leaves and chlorophyll 'a' content. But variance due to environment (linear) were found significant at one per cent level for all the characters except for total leaf dry matter yield per plant, moisture content of leaves. At 5 per cent level the characters total leaf dry matter yield per plant, moisture content of leaves at 18 and 24 hours after harvest were found significant. Whereas genotype X environment (linear) was highly significant for the characters plant height on 90th day, fresh weight of 25 leaves, internodal distance, chlorophyll ´b' and total chlorophyll content. And found significant at 5 per cent level of significane for leaf area per plant, leaf area index, leaf to stem ratio by fresh weight and stomatal frequency at both upper and lower surface of leaves. When their MSS tested against MSS of pooled deviation. Pooled deviation, the non-linear portion of variance which is the unpredictable portion of G X E interaction was observed to be highly significant (at p=0.01) for all the characters except for moisture content of leaves immediately after harvest, internodal distance and stomatal frequency at both lower and upper surface when their MSS were tested against pooled error.

Since the genotype X environmental interactions were found significant for maximum characters, the data was considered for stability analysis by estimating stability parameters as per Eberhart and Russell (1966).

4.3.3 Stability Analysis

In order to identify the stable genotypes for different characters, the stability analysis was carried out employing the linear regression model suggested by Eberhart and Russell (1966). According to the model, three stability parameters viz., mean ($\overline{X}$), regression coefficient (b_i) and means square deviations from linear regression line (S^2d_i) were computed for each of the 21 characters and the results obtained are presented characterwise in the paragraphs.

4.3.3.1 Plant height on 90th day

Stability parameters for plant height on 90th day are summarised in Table 8. Among the genotypes, the genotype Mysore Local was found to be tallest (137.45 cm). On the contrary cross Local/Kokuso S 13 found to be shortest showing plant height of only 95.02 cm. The regression coefficient (b_i) was not significant for all the genotypes. The deviation from regression (S^2d_i) was found to be not significantly different from zero in respect of crosses AB/Kokuso 13 (0.40), Mizusawa/Black cherry (4.87) and check M_5 (-0.94). While the other genotypes found to be significantly deviate from regression (s^2d_i -0), the crosses Miuasawa/Cattanoo, Mizusawa/Black cherry and AB/Kokuso 13 were not significantly different from regression coefficient (d_i =1) as well as deviation from regression ($S^2d_i=0$).

4.3.3.2 Number of leaves on 90th day

Among the crosses, Local/Kokuso 13 S_2 showed maximum number of leaves (161.29) whereas White Badana/Kosen showed minimum number of leaves (88.21). While others fell in between.

The regression coefficient (b_i) was found to be non significant for all the genotypes. The deviation from regression (S^2d_i) was not found to be significantly different from zero in respect of only one cross White Badana/Kosen (4.65). While the remaining genotypes were found to be significantly different from zero. The cross White Badana/Kosen was not signficantly different from regression coefficient ($b_i=1$) as well as deviation from regression ($S^2d_i=0$). Stability parameters for number of leaves on 90th day are summarised in Table 9.

4.3.3.3 Total leaf weight per plant

Table 10 illustrates the stability parameters of total leaf weight per plant. From the table we can conclude that the cross Sujanpur-1/Philippine S_1 found to have maximum leaf weight per plant and White Badana/kosen found to show minimum weight per plant and other genotypes were listed within this range.

The regression coefficient (b_i) was not significant from unity for all the genotypes. The deviation from regression (S^2d_i) was found to be significantly different from zero. In five crosses viz., Mizusawa/Cattaneo, Sujanpur-1/Philippine S_1, Sujanpur-1/Philippine S_2, AB/Kokuso 13, white Badana/Philippine and S_{54}. while it was not significant in respect of other genotypes. The crosses White Badana/Kosen, Local/Kokuso 13 S_1, Local/Kokuso 13 S_2, Mizusawa/Black cherry, Mysore Local and M_5 were not significantly different from regression coefficient (b_i=1) as well as deviation from regression (S^2d_i=0).

4.3.3.4 Fresh weight and dry weight of leaves

Stability parameters for fresh weight and dry weight of 25 leaves are presented in Table 11 and 12. Among the crosses Sujanpur-1/Philippine S_1 showed maximum fresh and dry weight (93.55 and 24.04 g) whereas cross White Badana/Philippine showed minimum fresh and dry weight (49.39 g and 10.89 g). The other genotypes fell in between.

The regression coefficient (b_i) for the charcter fresh weight of 25 leaves was not significant in all the genotypes studied. The deviation from regression S^2d_i was found to be significant different from zero in respect of ~~five~~ 4 crosses viz., Sujanpur-1/Philippine S_1, Sujanpur-1/Philippine S_2, AB/Kokuso 13, and S_{54}. The crosses Mizusawa/Cattaneo, White

Badana/Kosen, Local/Kokusa 13 S_1, white Badana/Philippine, Mizusawa/Black cherry and checks Mysore Local and M_5 were not significantly different from regression coefficient (b_i=1) and deviation from regression (S^2d_i=0).

The regression coefficient (b_i) for dry weight of 25 leaves was found to be significantly different from unity in respect of two crosses viz., Sujanpur-1/Philippine S_2 and AB/Kokuso 13. The deviation from regression (S^2d_i) was found to be significantly different from zero in respect of four genotypes viz., White Badana/Kosen, Sujanpur-1/Philippine S_2, Local/Kokuso 13 S_1 and check S_{54}. The crosses Mizusawa/Cattaneo, Local/Kokuso 13 S_1, white Badana /Philippine, Mizusawa/Black cherry and checks Mysore Local and M_5 were not significant from regression coefficient (b_i=1) as well as deviation from regression (S^2d_i=0).

4.3.3.5 Leaf area per plant

Stability parameters for this character are presented in Table 13. Among the crosses Sujanpur-1/Philippine S_1 possessed maximum leaf area per plant and White Badana/Kosen showed minimum leaf area per plant and other genotypes fell in between in these two.

The regression coefficient (b_i) was not significant in all crosses studied. The deviation from regression (S^2d_i) was found to be significantly different from zero in respect of two crosses and a check viz., White Badana/Kosen, Local/Kokuso 13 S_2 and S_{54}. The crosses Mizusawa/Cattaneo, Sujanpur-l/Philipine S_1, Sujanpur-l /Philippine S_2, Local/Kokuso 13 S_1, AB/Kokuso 13, White Badana/Philippine, Mizusawa/Black cherry and checks Mysore Local and M_5 were not significantly different from regression coefficient (b_i=1) as well as deviation from regression (S^2d_i=0).

4.3.3.6 Leaf area index

Among the genotypes, the cross Sujanpur-l/Philippine S_1 showed maximum leaf area index while White Badana/Kosen showed minimum leaf area index. All the other lines were listed within this range (Table 14).

The regression coefficient (b_i) was found to be non significant for all the genotypes. The deviation from regression (S^2d_i) was found to be significantly different from zero in respect of two crosses White Badana/Kosen, Local/Kokuso 13 S_2 and check S_{54}, while it was found to be non significant with respect to other nine lines. The crosses Mizusawa/Cattaneo, Sujanpur-l/Philippine S_1, Sujanpur-l/Philippine S_2, Local/Kokuso 13 S_1, AB/Kokuso 13, White Badana/Philippine, Mizusawa/Blcak cherry and checks

Mysore Local and M_5 were not significantly different from regression coefficient (b_i=1) as well as deviation from regression (S^2d_i=0).

4.3.3.7 Total leaf dry matter yield per plant

Stability parameters for this character are presented in Table 15. Among the crosses Local/Kokuso 13 S_1 possessed more leaf dry matter yield per plant and it was contradictory with White Badana/Kosen. other genotypes ranged in between these two. The regression coefficient (b_i) was not significant from unity in respect of all the characters studied. The deviation from regression (S^2d_i) was found to be significantly different from zero in respect of five crosses viz., Mizusawa/Cattaneo, White Badana/Kosen, Local/Kokuso 13 S_1, Local/Kokuso 13 S_2 and Mizusawa/Black cherry. The crosses Sujanpur-1/Philippine S_1, Sujanpur-1 /Philippine S2, AB/Kokuso 13, White Badana/Philippine and checks Mysore Local, M5 and S54 were not significantly different from regression coefficient (b_i=1) as well deviation from regression (S^2d_i=0).

4.3.3.8 Moisture content of leaves

Table (16) illustrates the stability parameters for moisture content of leaves immediately after harvest. Among the crosses White Badana/Philippine, showed maximum moisture content in leaves immediately after harvest. On the contrary the cross Mizusawa/Cattaneo showed minimum moisture content, while the other genotypes fell in between.

The regression coefficient (b_i) was found to be non significant from unity in respect of all the genotypes. The deviation from regression (S^2d_i) was also found to be non significantly different from zero with respect to all the genotypes. Therefore all the genotypes found non significant for both deviation from regression ($S^2d_i=0$) and regression coefficient ($b_i=1$).

Among the crosses studied for moisture content of leaves six hours after harvest, Mizusawa/Cattaneo was found to possess maximum moisture content. While the check Mysore Local found to have minimum moisture content.

The regression coefficient (b_i) was not significantly different from unity in respect of all the genotypes. The deviation from regression (S^2d_i) was found to be significantly different from zero in respect of three crosses viz., White Badana/kosen, AB/Kokuso 13 and White Badana/Philippine. The crosses Mizusawa/Cattaneo, Sujapur/Philippine sl, Local/Kokuso 13 S_2, Mizusawa/Black cherry and checks Mysore Local, M_5 and S_{54} were not significantly different from regression coefficient ($b_i=1$) as well as deviation from regression ($S^2d_i=0$). The stability parameters for moisture content of leaves six hours after harvest are summarised in Table 17.

Table 18 illustrates the stability parameters for moisture content of leaves twelve hours after harvest. From the table we can conclude that the cross Mizusawa/Cattaneo was found to have maximum moisture content (64.22%). On the contrary the cross Mizusawa/Black cherry found to have minimum moisture content (53.56%), while the other genotypes fell in between.

The regression coefficient (b_i) was not significant from unity in allthe genotypes. The deviation from regression (S^2d_i) was found to be significantly different from zero in respect of six crosses viz., White Badana/Kosen, Sujanpur-1/Philippine S1, Local/Kokuso 13 S1, Local/Kokuso 13 S2, AB/Kokuso 13, White Badana/Philippine and check M5, while it was found to be non significant in respect of other genotypes. The crosses Mizusawa/Cattaneo, Sujanpur-1/Philippine S2, Mizusawa/Black cherry, and checks Mysore lcoal and S_{54} were not significantly different from regression coefficient (b_i=1) as well as deviation from regression (S^2d_i=0).

Stability parameters for moisture content of leaves 18 hours after harvest are presented in Table 19. Among the crosses Mizusawa/Cattaneo found to possess maximum moisture content of leaves (56.21%) where as the cross Sujanpur-1/Philippine S1 found to contain minimum moisture (44.43%). The other genotypes ranged in between.

The regression coefficient (b_i) was found to be non significantly different from unity with respect to all the genotypes. The deviation from regression (S^2d_i) was significantly different from zero in respect of four crosses viz., White Badana/Kosen, Local/kokuso 13 S2, AB/Kokuso 13 and White Badana/Philippine. The genotypes Mizusawa/Cattaneo, Sujanpur-1/Philippine S1, Sujanpur-1/Philippine S2, Local/Kokuso 13 S1, Mizusawa/Black cherry, Mysore Local, M5 and S54 were found to be not significantly different from regression coefficient (b_i=1) and deviation from regression (S^2d_i=0).

Among the the genotypes studied for moiture content of leaves 24 hours after harvest, Mizusawa/Catteneo showed maximum moisture content of leaves (50.19%) whereas Sujanpur-1/Philippine S1 possessed minimum moisture content (39.41%). While the other genotypes fell in between.

The regression coefficient (b_i) was found to be not significantly different from unity in respect of all the genotypes. The deviation from regression (S^2d_i) was found to be significantly different from zero in respect of two crosses viz., AB/Kokuso 13 and white Badana/Philippine. The crosses Mizusawa/Cattaneo, White Badana/Kosen, Sujanpur-1/Philippine Sl, Sujanpur-1/Philippine S2, Local/Kokuso 13 Sl, Local/Kokuso 13 S2, Mizusawa/Black cherry and checks Mysore Local, M5 and S54 were not significantly different from regression coefficient (b_i=1) as well as deviation from regression (S2di=0) (Table 20).

4.3.3.9 Leaf to stem ratio by fresh weight

Stability parameters for this character are presented in Table 21. Among the crosses Local/Kokuso 13 S_2 showed highest leaf to stem ratio (0.72) while the genotype White Badana/Cattaneo had lowest leaf to stem ratio (0.33) other genotypes ranged in between.

The regression coefficient (b_i) was found to be non significantly different from unity in respect of all the genotypes. The deviation from regression coefficient (s2di) was found to significantly different from zero in respect of all the characters except the genotypes Local/Kokuso 13 S_2 and M5 which were not significant from zero. The cross Local/Kokuso 13 S2 and check M5 were not significantly difference from regression coefficient (bi=1) as well deviation from regression (s2di=0).

4.3.3.10 Internodal distance

Table 22 illustrates the stability parameters for internodal distance. From the Table we can conclude that the cross Mizusawa/Cattaneo possessed maximum internodal distance. On the contrary the check S54 showed minimum internodal distance, while the other genotypes fell in between.

The regression coefficient (b_i) was found non significantly different from unity in all the genotypes studied. The deviation from regression coefficient (S^2d_i) was found to be non significantly different from zero in respect of all the genotypes. Hence all the genotypes were not significantly different from regression coefficient (b_i=1) as well as deviation from regression (S^2d_i=0).

4.3.3.11 Chlorophyll content of leaves

Stability parameters for chlorophyll 'a' content are presented in Table 23. Among the genotypes M5 possessed maximum chlorophyll 'a' content (1.50 mg/g fresh weight) while, the cross Local/Kokuso 13 S2 had minimum chlorophyll 'a' content (1.21 mg/g fresh weight) and other genotypes ranged between these two limits.

The regression coefficient (bi) was not significantly different from unity in respect of all the genotypes. The deviation from regression (s2di) was found to be significantly different from zero in respect of six crosses viz., White Badana/Kosen, Sujanpur-l/Philippine S_1, Sujanpur-l/Philippine S_2, Local/Kokuso 13 Sl, Local/Kokuso 13 S2, white Badana/Philippine and check M5. The genotypes Mizusawa/Cattaneo, AB/Kokuso 13, Mizusawa/Black cherry, Mysore Local and S54 were found to be not significantly different from regression coefficient (bi=l) and deviation from regression (s2di=0).

Among the genotypes for chlorophyll 'b' content Mysore Local possessed maximum chlorphll'b' content, whereas S54 had minimum chlorophyll 'b' content, the other genotypes fell in between (Table 24).

The regression coefficient (bi) was found to be non significantly different from unity in respect of all the genotypes. The deviation from regression (s2di) was found to be significantly different from zero in respect of three crosses viz., Mizusawa/Cattaneo, Sujanpur-l/Philippine S2, White Badana/Philippine and check M5. The crosses White Badana/Kosen, Sujanpur-l/Philippine Sl, Local/Kokuso 13 Sl, Local/Kokuso 13 S2, AB/Kokuso 13, Mizusawa/Black cherry and checks Mysore Local and S54 were not significantly different from regression coefficient (bi=l) as well as deviation from regression (s2di=0).

Table 25 presents stability parameters for total chlorophyll content of leaves. The genotypes Mysore Local showed maximum chlorophyll content (2.26 mg/g fresh weight). On the contrary the genotype S54 possessed minimum chlorophyll content (1.86 mg/g fresh weight).

The regression coefficient (bi) has found to be non significantly different from unity with respect to all the genotypes. The deviation from regression (s2di) was significantly different from zero with respect of three crosses viz., Mizusawa/Cattaneo, Sujanpur-1/Philippine S1, AB/Kokuso 13 and check M5. while it was found non significant in respect of other genotypes. The crosses White Badana/Kosen, Sujanpur-1/Philippine S2, Local/Kokuso 13 S1, Local/Kokuso 13 S2, White Badana/Philippine, Mizusawa/Black cherry and checks Mysore Local and S54 were not significantly different from regression coefficient (bi=1) as well as deviation from regression (s2di=0).

4.3.3.12 Crude protein content of leaves

Stability parameters with respect to this character are presented in Table 26. among the genotypes S54 possessed maximum crude protein content (17.01%) whereas cross Sujanpur-1/Philippine S2 possessed minimum crude protein content (11.80%). The other genotypes fell in between.

The regression coefficient (bi) was found to be non significantly different from unity in respect of all the genotypes studied. The deviation from regression (s2di) was found to be significanty different from zero in respect of 5 genotypes viz., Sujanpur-1/Philippine S2, White Badana/Philippine, Mysore Local M5 and S54. While it was found non significant in respect of other seven genotypes. The crosses Mizusawa/Cattaneo, White Badana/Kosen, Sujanpur-1/Philippine S1, Local/Kokuso 13 S1, Local/Kokuso 13 S2, AB/Kokuso 13 and Mizusawa/Black cherry were found to be non significantly different from regression coefficient (bi=1) and deviation from regression (s2di=0).

4.3.3.13 Stomatal frequency on lower and upper surface of leaves

Among the genotypes for stomatal frequency on lower surface of leaves, the cross Mizusawa/Cattaneo found to have maximum stomatal frequency (3.68) while the cross AB/Kokuso 13 found to possess minimum stomatal frequency (1.11). All the other genotypes were listed within this range (Table 27).

The regression coefficient (bi) was found to be non significantly different from unity with respect to all the genotypes. The deviation from regression (s2di) was also found to be non significantly different from zero with respect to all the genotypes. Hence, all the twelve genotypes were found not significantly different from regression coefficient (bi=1) as well as deviation from regression (s2di=0).

Table 28 ilustrates stability parameters of stomatal frequency at upper surface of leaves. From the Table we can conclude that the cross Local/Kokuso 13 S1 found to contain maximum stomatal number (2.95) and cross Mizusawa/Black cherry found to possess minimum stomatal number. While the other genotypes fell in between these range.

The regression coefficient (bi) was found to be significantly different from unity in only one genotype M5 (0.16). While it was found non significnat in respect of other genotypes. The deviation from regression (s2di) was found to be signficantly different from zero in respect of cross Local/Kokuso 13 S2 and check S54, while it was found to be non significant in respect of other genotypes. The genotypes Mizusawa/Cattaneo, White Badana/Kosen, Sujanpur-1/Philippine S1, Sujanpur-1/Philippine S2, Local/Kokuso 13 S1, AB/Kokuso 13, White Badana/Philippine, Mizusawa/Black cherry and Mysore Local were not significantly different from regression coefficient (bi=1) as well as deviation from regression (s2di=0).

DISCUSSION

V DISCUSSION

The knowledge about the amount of genetic variability present in a crop species, different characters attributing towards yield and their association, nature and extent of relative contribution of different traits towards yield is important. The primary goal of a plant breeding programme is essentially to improve the genetic potentiality of a crop, particularly the yielding ability and productivity of a genotype. This is being achieved in several ways, the most attractive one being heterosis breeding. This has been exploited for long in cross pollinated crops. High yielding varieties or hybrids, before they are released for commercial cultivation need to be evaluated against the popular varieties for their yielding ability. Besides, identification of genotypes possessing adequate stability for economically important characters i.e., yield both over seasons and locations is also important. A good adopted variety is defined by Frey (1964) as the one which gives superior production over a range of environments. Thus naturally all the plant breeders are interested in developing varieties which would performed well under varied agroclimatic situations. But a specific genotype does not exhibit the same kind of performance well under varied agroclimatic situations and different genotypes do not respond in the same way to a specific environment. This kind of variation is attributed to the existance of interaction between genotype and environment. This has necessiated, for those engaged in crop improvement programme, to strive hard for reducing the magnitude of interaction between the genotype and the environment. To achieve this, some researchers has suggested stratification of the environment and developing suitable genotypes for each such environments.

This again will not be a permanent solution for the problem as there exists considerable interaction of the genotype with the environment (seasons or locations). and thus one cannot expect for the same climtic conditions to prevail over seasons/years (Eberhart and Russell, 1966). Some workers like Finley and Wilkinson (1963) have used and recommended Logarithmic transformation of the data to reduce the interaction. But this remains a theoretical proposition and does not provide practical solution. Later scientists tried to develop certain statistical and genetic models to facilitate, identification of genotypes which interact to the minimum extent with the environments.

In the present investigation twelve genotypes including nine hybrids and three check varieties of mulberry were grown in three different environments viz., Kharif, Rabi and Summer by adopting Completely Randomised Block Design (RCBD). The study was aimed at estimating the magnitude of yield variability, heterosis for leaf yield, identifying stable plant characters in mulberry as selection criteria and mainly identification of stable genotypes for leaf quality characters.

Discussion were made for each objective, based on the results obtained on twelve genotypes over three environments under the following headings:

1. Yield variability
2. Magnitude of heterosis
3. Performance of genotypes in different environments
4. Genotype X environment interactions
5. Stability for individual characters

5.1 Yield variability

The mean performances of twelve clones was observed for leaf yield and related traits in three harvests. Analysis of variance revealed high significant differences for all the characters studied indicating the genotypic differences among the clones. Fresh leaf yield per plant, leaf dry matter per plant, number of leaves per plant and leaf area per plant recorded during three harvests and total of these observations over three harvests showed significant differences among the clones over three harvests at one per cent level. This suggests that sufficiently high variability exists for the characters studied and considerable improvement can be achieved in these characters by selection.

Significant difference among the clones were evident for all the leaf yielding and other related characters studied, which can be attributed for the effect of genotypes. These results are in agreement with the research findings of Anon., 1970a and 1970b; Dandin et al., 1983; Bari et al., 1988 a, Susheelamma and Jolly, 1986; Jolly and Dandin, 1986; Bhat, 1989 and Varanagabushan, 1990.

Some of the hybrids like Mizusawa/Cattaneo, Local/Kokuso 13 S1, Sujanpur-1/Philippine S1, Sujanpur-1/Philippine S2 and check variety S54 showed greater variability with respect to leaf yield. These results are on par with research findings of (Bhat, 1989 and Vranagabushan, 1990).

5.2.1 Magnitude of heterosis

Comparison of hybrids with the best ones among the released varieties is more important than their performances above their parents i.e., relative heterosis (mid parent) and heterobeltioses. Hence, estimation of standard heterosis is given importance in the present study and a characterwise discussion is presented .

In plant height seven hybrids showed positive standard heterosis over check variety M5 and eight hybrids showed positive standard heterosis with respect to the check variety S54. These hybrids did not show heterosis for yield except some hybrids with respect to M5 check i.e., Mizusawa/Cattaneo, Sujanpur-1/Philippine S1, Local/Kokuso 13 S1, and over S54 check Mizusawa/Cattaneo, Sujanpur-1/Philippine S1, Sujanpur-1/Philippine S2, Local/Kokuso 13 S1. Since, plant height is a vegetative character and not necessarily be correlated with yield, care shoud be taken while selecting parents for heterosis breeding programme. However, increased height due to hybrid vigour can definitely increased the harvest index and ultimately yield.

Two hybrids viz., Local/Kokuso 13 S1 and AB/Kokuso 13 showed positive standard heterosis for number of leaves over M5 check. Six hybrids manifested positive standard heterosis over S54 indicating that these hybrids have got higher leaf production potential than the commercially popular varieties. These results are on par with research findings of Abdullaevik et al. (1962), Rahmanberdyev, 1968; Hidan et al., (1978), Penkovi (1979) and Dandin et al., (1983).

Number of branches is an important character, being one of the principle yield components. Two hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S2, showed positive standard heterosis over M5 check variety. The same two hybrids over S54 manifested positive standard heterosis indicating that these hybrids produced more number of branches than the check varieties.

Internodal distance is one of the important characters. Since it decides the leaf yield. Lesser the internodal distance more is the number of leaves per branch, theirby, contributing to increased leaf yield. All the nine hybrids showed positive standard heterosis over both the check varieties. Similar conclusions were drawn by Dandin et al., (1983).

Fresh and dry weight of mulberry leaves is also one of the yield components. Hybrids Mizusawa/Cattaneo, Sujanpur-1/Philippine S2 and Mizusawa/Black cherry showed positive standard heterosis over M5 and the same hybrids showed positive standard heterosis with respect to S54 check indicating superiority of hybrids over check varieties. Similar results were obtained by Hidan et al., (1978) and Dandin et al. (1983).

Heterosis for fresh weight of stem was significant in two hybrids while one hybrid expressed significant positve standard heterosis over M5. Three hybrids showed significant standard heterosis with respect to S54 check indicating that some hybrids possessed more stem weight compared to check varieties. Stem dry weight in four hybrids showed significant standard heterosis with respect to M5 check. Five hybrids over S54 manifested significant positive standard heterosis indicating superiority of hybrids over checks.

Hybrid Local/Kokuso 13 S2 manifested significant positive standard heterosis for leaf to stem ratio over M5. The same two hybrids with respect to S54 exhibited significant positive standard heterosis indicating possible scope for exploitation of this character.

Moisture percentage showed positive standard heterosis with six hybrids over M5 check immediately after harvest of the leaves. Three hybrids showed positive standard heterosis after 6, 12, 18 and 24 hours of harvest. Three hybrids over S54 manifested positive standard heterosis after 6, 12, 18 and 24 hours after harvest indicating superiority of this character over check varieties. These results are on par with the findings of Craiciu (1969), Dandin et al., 1983. Contradictory results were reported for this character by Bhat, 1989. He reported high moisture content in check variety S54.

Considering heterosis of chlorophyll content of leaves. All the hybrids showed negative standard heterosis over M5 check for chlorophyll 'a' content of leaves. Three hybrids showed positive standard heterosis for chlorophyll ´a' over S54 check. For chlorophyll "b" three hybrids manifested positive standard heterosis over check M5 and all the hybrids manifested positive standard heterosis over S54 check variety. For total chlorophyll content one hybrid showed positive standard heterosis over M5 and all the hybrids except Local/Kokuso 13 S2 showed positive standard heterosis over S54. These results indicated that none of the hybrids showed superiority over M5 check for chlorophyll ´a' but three hybrids showed superiority over S54 check. For chlorophyll ´b' content, three hybrids showed superiority over M5 chek and all the hybrids showed superiority over S54 check. Total chlorophyll content was superior over M5 check in one hybrid. Eight hybrids showed maximum total chlorophyll content over S54 check. These results are on par with the findings of Hidan et al. (1978) and Susheelamma (1990). Higher chlorophyll content has also been reported in hybrids by Bhat (1989) and Varanagabushan (1990).

Crude protein content showed positive standard heterosis for all the hybrids except Sujanpur-1/Philippine S1, AB/Kokuso 13 over M5 check. All the hybrids with respect to S54 showed negative standard heterosis, indicating superiority of hybrids over M5 but none of the hybrids were superior over S54 check variety. These results are in agreement with research findings of Craiciu (1969), Anon., (1970) and Hidan *et al*. (1978). Higher crude protein percentage has also been observed in some of the hybrids by Bhat (1989) and Varananagabushan (1990).

Stomatal frequency in the leves decides transpiration loss and moisture retention capacity of the leaves. Usually more number of sotmatas are observed under lower surface of the leaves. It is genetically controlled character the number remains the same within the variety but significantly differs between the varieties. Three hybrids showed negative standard heterosis over M5 and the same three hybrids showed negative standard heterosis over S54 check. These results indicated that those showed negative standard heterosis were superior to check varieties.

Stomata on the upper surface of the leaves showed negative standard heterosis in Mizusawa/Black cherry over M5 check. Three hybrids manifested negative standard heterosis over S54 check indicating superiority of the hybrids over check.

Considering the heterosis of total leaf weight per plant, three hybrids exhibited positive standard heterosis over the check variety M5. The same hybrids showed positive standard heterosis over S54. These results indicates the possible scope for exploitation of hybrid vigour of this character and for realising still higher yields. These results are in agreement with research findings of Abdullaevik et al., 1962; Shablovskayami and Kafian, 1967; Rahmanberdyev, 1968; Craiciu, 1969; Hidan et al., 1978; Fonseca, 1978; Penkovi, 1979; Kuchkarov, 1981 and Hidan et al., 1982.

Leaf area index showed significant positive standard heterosis over M5 check variety. Three hybrids manifested significant positive standard heterosis over S54 check indicating superiority of this particular characters over check varieties. Bhat (1989) reported higher leaf area index in some of the hybrids compared to M5 check variety but with respect to S54 check variety. Contradictory results were observed i.e., S54 showed higher leaf area index over all the genotypes studied. The contradictory results were observed for both the check varieties M5 and S54 in research findings of Varanagabushan (1990).

Leaf area per plant showed significant positive standard heterosis in two hybrids over M5. Four hybrids exhibited significant positive standard heterosis with respect to check variety S54, thereby realising superiority of hybrids over check varieties. These results are on par with research findings of Shablovskayami and Kafian (1967), Hidan et al., (1978) and Hidan et al., (1982).

Total leaf dry matter per plant manifested significant positive standard heterosis in two hybrids over M5 and three hybrids showed significant positive standard heterosis with respect to S54 check variety indicating possible chance for exploitation of the hybrid vigour in these hybrids. These results are in agreement with Hidan et al., (1978). These results imply that an indepth study is needed to see if the sterility percentage is the reason for non expression of heterosis for yield. Although considerable heterosis has been seen in respect of yield components. It is therefore suggested to take up path analysis study in reasoning the yield fluctuations in hybrids. Among the nine hybrids studied Mizusawa/Cattaneo, Sujanpur-1/Philippine, Local/Kokuso 13 S1 performed better over both the check varieties M5 and S54 for fresh leaf yield per plant. Hybrids Mizusawa/Cattaneo, AB/Kokusa 13, White Badana/Philippine and Local/Kokuso 13 S2 were better than the M5 check and hybrids Mizusawa/Cattaneo, AB/Kokusa 13 and White Badana/Philippine were superior over S54 check for moisture content in leaves. For crude protein content hybrids Sujanpur-1/Philippine S1, and AB/Kokuso 13 showed beter performance over M5. All the crosses that showed positive significant heterosis over the checks, manifested increased hybrid vigour and indicate that improvement for these characters can be done by production of F_1 hybrids in Morus spp.

5.3.1 Performance of genotypes in different environments

The data obtained from 12 diverse genotypes with nine crosses and three checks of mulberry for each of the 21 characters were analysed individually to find the performance of genotypes in all the three environments. The mean performance of the genotypes in each environments for different characters were presented in the Tables 8 to 28. Such of the four genotypes as found to be the best performing for each character in each of the environments are given in Table 31. Further genotypes stable overall the three environments are also given in Table 31.

As indicated by the environmental means Kharif (E1) environment found to be more favourable for plant height on 90th day (129.12) followed by Summer (E3) environment (109.40) and Rabi (E2) environment (102.02). Mysore Local was found to be the tallest. List of the genotypes suitable to different environments for maximum plant height are given in Table 31.

Summer (E3) environment was found to be more favourable for more number of leaves on 90th day (133.37) followed by kharif (E1) environment (134.56). Local/Kokuso 13 S1 was found to possess maximum number of leaves in all the environments. List of the genotypes suitable to different environments for number of leaves are given in Table 31.

Total leaf wight was found to be maximum in the kharif (E1) environment as indicated by environmental mean 202.06 g. On the contrary rabi (E2) environment found to show minimum weight (167.06 g). Among all the crosses and checks studied Sujanpur-1/Philippine S1 was found to possess maximum leaf weight (232.66 g) in all the environments. Other genotypes varied in total leaf weight, better genotypes suitable to different environments are listed precisely in Table 31.

kharif (E1) environment was found to be more favourable for higher fresh weight of 25 leaves (81.07 g) followed by rabi (E2) environment (72.84 g) and summer (E3) environment (64.89 g). Eventhough some of the genotypes exhibited uniform fresh weight over the environments, majority of the genotypes varied in their fresh weight in different environments. Genotypes suitable for different environments for varying fresh weight of 25 leaves are given in Table 31.

Environments had negligible influence on dry weight of 25 leaves as indicated by a narrow range of environmental means. However, kharif (E1) environment was found to be more favourable for better expression of this character, where it gave 19.31 g of dry weight. Genotypes differed in their performance in different environments are given in

Table 5 and list of suitable genotypes for different environments are given in Table 31.

Summer (E3) environment was found to be more favourable for leaf area per plant (88660.16 cm^2) followed by kharif (El) environment (8645.14 cm2) and rabi (E2) environment (6174.58 cm2). Among the genotypes, Sujanpur-l/Philippine Sl, Mizusawa/Cattaneo were found to possess maximum leaf area per plant in most of the environments. However, genotypes were not uniform over environments in respect of leaf area per plant. Some of the suitable genotypes for different environments under study are listed in Table 31.

Variety environmental means (1.37 to 2.45) and environmental indices (-0.70 to 0.37) indicating greater influence of environment on this character. To get higher leaf area index summer (E3) environment was found to be more favourable as it gave 2.45 maximum mean. On the contrary rabi (E2) environment was found to be less favourable **for this character** (1.37). Among the genotypes Sujanpur-l/Philippine Sl, Local/Kokuso 13 S_1 Mizusawa/Cattaneo are found to give maximum leaf area index. But they found to vary from environment to environment. List of genotypes in respect of high leaf area index for different environments are given in Table 31.

In respect of total leaf dry matter yield per plant, Local/Kokuso 13 S1 and Sujanpur-1/Philippine S1 were found to be uniform over the years with a mean yield of 60.81 g and 57.12 g. Remaining genotypes varied in their yielding ability from environment to environment indicating the influence of environments on the expression of this character. Among the three environments, kharif (E1) environment was found to be more favourable for higher total leaf yield dry matter per plant (48.37 g) whereas summer (E3) environment was favourable for lower total leaf yield per plant (39.78 g). List of the genotypes which performed well only a in a specific environments are given in Table 31.

As indicated by the environmental means kharif (E1) environment found to be more favourable for moisture content of leaves immediately after harvest (77.91%) followed by rabi (E2) (76.35%) and summer (E3) environment (75.97%). S_{54} check was found to show maximum moisture content in all the environments. Genotypes suitable to different environments for moisture content of leaves immediately after harvest are given in Table 31.

Moisture content of leaves six hours after harvest found to show maximum percentage of moisture in kharif (E1) as indicated by environmental means of 70.82 per cent. On the contrary summer (E3) environment showed minimum percentage of moisture content (67.44%). Among the genotyes, Mizusawa/Cattaneo was found to possess maximum percentage of moisture in all the environments under study. Better genotypes suitable for different environments are given precisely in Table 31.

kharif (E1) environment was found to be more favourable for higher moisture content of leaves after 12 hours of harvest (62.23%) followed by summer (E3) environment (59.64%) and rabi (E2) environment (59.03%). Eventhough some of the genotypes exhibited uniform moisture content over the environments, majority of the genotypes varied in their moisture content in different environments. Genotypes suitable for different environments for moisture content of leaves 12 hours after harvest are given in Table 31.

Environments had little influence on moisture content of leaves at 18 hours after harvest as indicated by a narrow range of environmental means. However, kharif (El) environment was found to be more favourable for better expression of this character where it gave 52.53 per cent of moisture content. This was followed by summer (E3) environment (52.35%) and kharif (El) environment (48.10%). Genotypes differed in their performances in different environments are given in Table 12. List of suitable genotypes for different environments are given in Table 31.

Summer (E3) environment was found to be more favourable for higher moisture content of leaves at 24 hours after harvest (46.53%) followed by kharif (E1) environment (45.36%) and rabi (E2) environment (41.62%). among the genotypes Mizusawa /Cattaneo found to show maximum moisture content of leaves in most of the environments. However, genotypes were not uniform over environments in respect of moisture content of leaves at 24 hours after harvest. Some of the suitable genotypes for different environments under study are listed in Table 31.

Variety environmental mean (0.50 to 0.52%) and environmental indices (-0.04 to 0.10) indicating the greater influence of environment on this character. To get higher leaf to stem ratio by fresh weight summer (E3) environment was found to be more favourable as it gave higher leaf to stem ratio (0.66). On the contrary kharif (E1) environment was found to be less favourable for this character. Among the genotypes, Local/Kokuso 13 S2 was found to possess higher leaf to stem ratio by fresh weight. But they found vary from environment to environment (Table 21). List of genotypes in respect of highest leaf to stem ratio by fresh weight for different environments are listed in Table 31.

Environments had very little influence on internodal distance as indicated by narrow range of environmental means. However, kharif (E1) environment was found to be more favourable for better expression of this character where it produced 3.90 cm in length. This was followed by summer (E3) environment (3.89 cm). Genotypes differed in their performances in different environments are given in Table 22. List of suitable genotypes for different environments are given in Table 31.

With respect of chlorophyll ´a' content, M5 genotypes was found to be uniform over the environments, with mean yield of 1.50 mg/g fresh weight, other genotypes varied in their chlorophyll ´a' content from environment to environment (Table 23) indicating the influence of environments on the expression of this character. Among the three environments kharif (E1) environment was found to be more favourable for chlorophyll ´a' content (1.4619 mg/g fresh weight). List of genotypes which performed well in specific environments are given in Table 31.

As indicated by the environmental means kharif (E1) environment found to be more favourable for chlorophyll ´b' content (0.705 mg/g fresh weight) folllowed by rabi (E2) (0.613 mg/g fresh weight) and summer (E3) environment (0.59 mg/g fresh weight), Mysore Local and Local/Kokuso 13 S2 were found to possess maximum chlorophyll 'b' content in all the environments. List of genotypes suitable to different environments for chlorophyll 'b' content are presented in Table 31.

Kharif (E1) environment was found to more favourable for total chlorophyll content (2.17 mg/g fresh weight) followed by rabi (E2) environment (1.99 mg/g fresh weight) and summer (E3) environment (1.88 mg/g fresh weight). Even though some of the genotypes exhibited uniform total chlorophyll content over the environments, majority of the genotypes varied in their total chlorophyll content (table 25). Genotypes suitable for different environments for varying chlorophyll content are given in Table 31.

Variety environmental means (11.36 to 16.52) and environmental indices (-2.86 to 2.30) indicating the greater influence of environment on this character. Higher crude protein content in summer (E3) environment was found to be more favourable as it gave 16.52 per cent of crude protein. On the contrary kharif (E1) environment was found to be less favourable for this character (11.36%). Among the genotypes S54 and AB/Kokuso 13 found to possess maximum crude protein content in all the environments other genotypes found to vary from environment to environment (Table 26). List of genotypes in respect of protein content for different environments are listed in Table 31.

Stomatal frequency on the lower surface of leaves, the cross White Badana/Kosen found to possess minimum number of stomata and was uniform over the environments with a mean of 1.30/microscopic field. Remaining genotypes varied in their stomatal number from environment to environment (Table 24) indicating the influence of environments on the expression of this character. Among the three environments kharif (El) environment was found to be more favourable for stomatal frequency at lower surface (2.38). List of genotypes which performed well only in specific environments are given in Table 31.

As indicated by the environmental means kharif (El) environment found to be more favourable for stomatal frequency on upper surface of leaves (2.14) followed by summer (E3) environment (2.13) and rabi (E2) environment (1.45), Mizusawa/Black cherry and M5 were found to show lower stomatal frequency in all the environments. List of the genotypes suitable for different environments for stomatal frequency on upper surface of leaves are given in Table 31.

5.3.2 Genotype X environment interaction

Genotype x environment interaction are of major importance to the plant breeders in developing improved varieties. This interaction is usually present and it reduces progress from selection (Comstock and Moll, 1963; Singh et al., 1974). Selection of stable genotypes that interact less with the environemnts in which they are grown, are known to reduce genotypeX environment interaction to a considerable extent (Allard and Bradshaw, 1964). Genotypes which interact less with the environments are selected and aid the breeder to a greater extent in developing suitable genotypes.

In the present investigation to identify and estimate genotype X environment interaction the statistical procedure given by Sundararaj et al. (1976) has been adopted. This revealed significant differences among the genotypes, environments as well as genotype X environment interaction for all the 21 characters (Table 29). Only after testing significants of overall G X E interaction and as it found significant, the determination of stability parameters for each of the genotypes was computed.

The analysis of variance as per Eberhart and Russell (1966) revealed significant differences among the genotypes for all the characters (Table 30). The additive environmental variance was found to be considerable as indicated by the significance of environment (linear) for all the characters. Pooled deviation (non linear) were significant for most of the characters indicating that this portion which is unpredictable, formed a major part of the G

X E interaction. However, GE interaction (linear) and pooled deviation mean squares (non linear) were found to be significant for the characters, plant height on 90th day, fresh weight of leaves, leaf area per plant, leaf area index, leaf to stem ratio by fresh weight, chlorophyll ´b' content and total chlorophyll content indicating the contribution of both linear and non-linear components towards the GE interaction variance of these characters. The more pronounced linearity for plant height on 90th day, fresh weight of leaves, leaf area per plant, leaf area index, leaf to stem ratio by fresh weight, chlorophyll ´b' content and total chlorophyll content indicated that the variations among the genotypes could largely explained by differences in regression slopes for these characters. This obviously indicated that the accurate prediction of phenotypic performances of the genotypes can be reduced for these characters, but such predictions are not possible for other characters due to the pronounced non linearity. Bari (1990) also observed significant pooled deviation for total leaf yield (non linear). Thus, it can be inferred that there is no simple relationship between the genotypes and the environments exists and therefore, it is rather difficult to predict the performance of the genotypes across the environments.

5.3.3 Stability for individual characters

Stability analysis was carried out by using the linear regression model proposed by Eberhart and Russell (1966). Although there are number of models available to characterise the genotypes for their GXE interaction, in effect the stability, this model is widely used for its simplicity and reliability. This model is also being used by Bari et al. (1990) in mulberry. In the present investigation, this analysis indicated the genotypes differed significantly in their response to varying environments in respect of twenty-one characters.

When once the GXE interaction was found significant the next task was to identify the stable genotype which interacted less with the environment and thus perform closer to the consistency across the environments. The model employed in this investigation considered three parameters viz., (1) Mean (μ)-performance (2) Regression coefficient (b_i)-cultivar means are regressed against environmental indices, i.e., a predictable response by a cultivar to either good or poor environments, and (3) deviation from regression (S^2d_i) a measure of genotype X environment interaction unpredictable type.

An ideal stable genotype is defined as the one possessing high mean performance, with re ion coefficient around unity (b_i=1) and with least deviation from regression coefficient i.e., as close to zero as possible. The linear regression is regarded as the measure of response of a particular genotype. If regression coefficient (b_i) is greater than unity the genotype is said to be highely sensitive to environmental changes but adapted to high yielding environments. If bi is equal to unity it indicates average sensitivity to environmental changes and adaptability to all environments. If bi is less than unity (1.00), it indicates less sensitivity to environments and if this is accompanied by a high mean value, then the genotype is said to be better adapted to widely differing conditions. If the mean is low, it can be interpreted that the genotypes is poorly adapted to all environments. Performances of highly sensitive, average sensitive and less sensitive genotype cannot be predicted when we grow in different environments.

In the present study stability parameters such as mean (existing), regression coefficient (b_i=1) and the deviation from regression coefficient (s^2d_i), as close to zero as possible) suggested by Eberhart and Russsell (1966) were considered to explain and discuss the stability of different genotypes for various characters under consideration.

Plant height on 90th day

Among the genotypes, cross Mizusawa/Cattaneo and AB/Kokuso-13 were found to be stable for this character over three environments as indicated by regression coefficient (b_i=1) and mean square deviation (S^2d_i=0). Mizusawa/Cattaneo was found to tallest over all the three environments.

The genotypes Mysore Local and crosses White Badana/Philippine, Local/Kokuso 13 S1, White Badana/Kosen, Sujanpur-1/Philippine S2, Sujanpur-1/Philippine S1, even though possessing high mean and unit regression were significantly deviated from mean squares deviation (S^2d_i=0). Hence they are classified under average sensitive genotypes. This indicates their sensitivity to all environments with unpredictable performances.

The cross Mizusawa/Black cherry was found to be highly sensitive to environment as indicated by their unit regression value exceeding unity. Since this genotype also possessed high mean value it could be adopted to high yielding environments.

The checks, M5 and S54 in addition to mean values, also possessed regression coefficient less than one. thus these genotypes were classified under low sensitive to environmental variations. this indicates their poor adoptability to all environments under study.

Number of leaves on 90th day

The environments influenced much for the expression of this character as revealed by varied environmental indices and environmental means. Genotypes, stability parameters, regression coefficient was not significantly deviated from unity for all the genotypes. Where as, the deviation from regression was found to be significant for all the characters except for the cross White Badana/Kosen. thus no genotypes was found to be stable for this character.

Crosses Mizusawa/Cattaneo, Sujanpur-1/Philippine S1, White Badana/Philippine and check M5 were found to be highly sensitive to environment as indicated by their regression coefficient exceeding unity. Thus these genotypes better suited to favourable environments, but as they were not stable their performances cannot be predicted early when grown in different environments.

Regression coefficient (b_i) was found to be less than one for White Badana/Kosen, Sujanpur-1/Philippine S2, AB/Kokuso 13, Check S54 indicating their less sensitiveness to environment. Thus these genotypes were suitable to all environments but their performance was poor as indicated by their low mean and performance could not be easily predicted.

Two genotypes with average and above average mean, did not significantly deviate from unit regression coefficient but they were deviated from mean square deviation (S^2d_i). Hence these genotypes were classified under average sensitive genotypes. They are suitable to all environments. However their performances cannot be easily predicted as they were not stable.

Total leaf weight per plant

As for the stability parameter, one cros Local/Kokuso 13 S2 found to be stable for this character as indicated by regression coefficient (b_i=1) and mean square deviation (S^2d_i=0).

The genotypes Mizusawa/Cattaneo, Sujanpur-1/PhilippineS2, Local/Kokuso 13 S1, were found to be highly sensitive to environmental fluctuations (bi more than one) indicating their better suitability to highly favourable environments. Since they were not found to be stable their performance may not be predicted when they grown in different environments.

Regression coefficient(bi) was found to be less than unity for White Badana/Kosen, Sujanpur-1/Philippine S2, White Badana/Philippine, Mizusawa/Black cherry, Mysore Local and M5 indicating their poor adaptability to all environments. Their performances also cannot be predicted. Similar results in other genotypes were observed by Sarkar et al. (1986) and Bari et al. (1990).

Fresh weight and dry weight of leaves

For fresh weight of 25 leaves 12 genotypes were not significantly deviated from regression coefficient (b_i=1) and six genotypes were found not significantly deviated from mean square deviation (S^2d_i=0). Two genotypes viz., Mizusawa/Cattaneo and White Badana/Kosen were found to be suitable over three environments for this character.

Genotype Mizusawa/Black cherry was highly sensitive to environmental fluctuations (bi more than one) with high mean performances indicating its suitability to high yielding (more favourable) environment. As it was not stable its performance cannot be easily predicted when grown in different environments.

Low mean coupled with regression coefficient (b_i) less than one indicated that Local/Kokuso 13 S1 and White Badana/Philippine were sensitive to environmental fluctuations and performance over the environments is unpredictable.

Even though Sujanpur-1/Philippine S2 was found to be less sensitive to environment, their high mean performance indicates their better adaptability to widely differing conditions with unpredictable performances when grown in different environments.

Remaining genotype M5 and S54 were of average response to environmental variations indicating that they are suitable to all environments. When they grown over environments their performances may not be easily predicted.

Stability parameters bi and s2di indicates that White Badana/Philippine was found to be stable for dry weight of leaves over three environments. It also indicated their performance could be predicted well over all the environments studied.

The crosses Mizusawa/Cattaneo, Local/Kokuso 13 S1 were found to be highly sensitive to environmental fluctuations as indicated by regression coefficient (bi is more than one) and mean square deviation ($S^2d_i=0$). It indicates their stability to more favourable environments with unpredictable performances when grown in different environments. On the contrary the genotypes, Local/Kokuso 13 S2, and Mysore Local were found very less sensitive to environment with poor mean performance, which indicates their poor adaptability overall the environments studied.

The regression coefficient (b_i) was found to be equal of one for the following genotype viz., White Badana/Kosen, Badana/Kosen, White Badana/Philippine, Mysore Local and M5 were found to be less sensitive to environmental fluctuations (bi=less than one) indicating their poor adaptability to all environments with unpredictable performances.

Leaf area index

The effect of environments was more for the expression of this character as revealed by varied environmental indices and environmental means. The stability parameter and regression coefficient was not significantly deviated from unity for all the genotypes whereas, the deviation from regression was found to be not significant for all the genotypes except for White Badana/Kosen, Local/Kokuso 13 S2 and M5. The crosses Mizusawa/Cattaneo and Sujanpur-1/Philippine S2 was found to be stable for this character.

For genotypes Sujanpur-1/Philippine S1, Local/Kokuso 13 S1 and Local/Kokuso 13 S2 were found to be highly sensitive to environment as indicated by their regression coefficient exceeding unity, thus these genotypes were better suitable to favourable environments, but as they were not stable their performances cannot be predicted when grown in different environments.

Regression coefficient (b_i) was found to be less than one for White Badana/Kosen, AB/Kokuso 13, White

Sujanpur-1/Philippine s1, indicates their average sensitivity to environmental fluctuations. But they can be suitable to all types of environments being studied. As they are not stable their performances cannot be easily predicted when grown over environments.

Leaf area per plant

Among the 12 genotypes studied the cross Sujanpur-1/Philippine S2 observed to be stable for this characters as indicated by regression coefficient (b_i=1) and mean square deviation from regression (S^2d_i=0).

As per stability parameters, Mizusawa/Cattaneo, Local/Kokuso 13 S2, AB/Kokuso 13, Mizusawa/Black cherry and S54 were found to be average sensitive to environments. thus they were suitable to all the environments with unpredictable performance.

As the regression coefficient exceeding unity for Sujanpur-1/Philippine S1 and Local/Kokuso 13 S1 they were found to be highly sensitive to environmental fluctuations but they are more suitable to favourable environments compared to their performances under less favourable environments. As these genotypes were not stable when grown in different environments, their performance may not be predicted very easily. On the contrary crosses White

Badana/Philippine, Mysore Local and M5 indicating their less sensitive to environment. Thus these genotypes were suitable to all environments but their performances will be very poor as indicated by low mean. Their performance also cannot be easily predicted. Two genotypes with above average mean, did not significantly deviated from unit regression coefficient but were deviated from mean square deviation (S^2d_i). Hence these genotypes were classified under average sensitive genotypes. They were suitable to all environments. However, their performances cannot be easily predicted as they were not stable.

Total leaf dry matter per plant

As per the stability parameters, none of the genotypes were found to be stable for total leaf dry matter yield per plant as indicated by regression coefficient (b_i=1) and mean square deviation (S^2d_i=0).

The genotypes, Local/Kokuso 13 S1, Mizusawa/Cattaneo, S54 were found to be highly sensitive to environment as indicated by their unit regression value exceeding unity. Since these genotypes also possessing high mean value they can be adapted to high yielding environments.

The genotypes White Badana/Kosen, Sujanpur-1/Philippine S2, AB/Kokuso 13, White Badana/Kosen, Mizusawa/Black cherry, Mysore Local and M5 in addition to mean values they also possessed regression coefficient less than one. Thus these genotypes were classified under low sensitive to environmental variations. This indicates their poor adoptability to all environments under study.

Moisture content of leaves

Among twelve genotypes only three crosses Local/Kokuso 13 S2 and checks Mysore Local and M5 were found to be sable for this character over three environments as indicated by regression coefficient (b_i=1) and mean square deviation (S^2d_i=0).

The genotypes S54 was found to be highly sensitive to environment as indicated by their unit regression value exceeding unity. Since these genotypes also possessed high mean value they can be adopted to high yielding environments.

The genotypes, Mizusawa/Cattaneo, Sujanpur-1/PhilippineS2, Local/Kokuso 13 S2, AB/Kokuso-13, White Badana/Philippine in addition to mean values they also possessed regression coefficient less than one. Thus these genotypes were classified under low sensitive to environmental variations. This indicated their poor adoptability to all the environments under study.

For moisture content of leaves 6 hours after harvest all the genotypes were found to be not significantly deviated from regression coefficient (b_i=1) and nine genotypes were found to be not significantly deviated from mean square deviation (S^2d_i 0). None of the genotypes found stable for this character.

Genotypes, Local/Kokuso 13 S1 and S54 was highly sensitive to environmental fluctuations (bi more than one) with high mean performance, indicating its suitability to high yielding (more favourable) environments. As it was not stable its performance cannot be easily predicted when grown in different environments.

Low mean coupled with regression coefficient (b_i) less than one indicates Local/Kokuso 13 S1, Mysore Local has got less sensitivity to environmental fluctuations. Thus it is adapted to all environments and its performances over the environments is unpredictable. Even though Mizusawa/Cattaneo, AB/Kokuso 13, White Badana/Philippine found to be less sensitive to environment their high mean performances indicates their better adoptability to widely differeing conditions with unpredictable performances when grown in different environments.

The genotypes, Sujanpur-1/Philippine S1, Sujanpur-1/Philippine S2, and M5 were of average response to environmental variations indicating that they are suitable to all environments. When they grown over environments their performances may not be easily predicted.

Stability parameters bi and s2di indicates none of the genotypes are stable for moisture content of leaves 12 hours after harvest over three environments. The crosses White Badana/Kosen, Myosre Local and S54 were found to be highly sensitive to environmental variations as indicated by regression coefficient (bi more than one) and mean square deviation (S^2d_i=0). It indicates their stability to more favourable environments with unpredictable performance when grown in different environments. On the contrary Mizusawa/Black cherry, Sujanpur-1/Philippine S1, Local/Kokuso 13 S1, were found less sensitive to environment with poor performance, which indicates their low adaptability over different environments studied.

The regression coefficient (b_i) was found to be equal to one for the following genotypes Sujanpur-1/Philippine S2, AB/Kokuso 13 indicates their average sensitivity to environmental fluctuations and they can be suitable to all types of environments being studied. As they were not stable their performances cannot be easily predicted when grown over environments.

Among the 12 genotypes studied for moisture content of leaves 18 hours after harvest, the cross Sujanpur-1/Philippine S2 was found to be stable as indicated by regression coefficient (b_i=1) and mean square deviation from regression (S^2d_i=0).

As per stability parameters White Badana/Kosen was found to be moderately sensitive to different environments. Thus this genotype is suitable to all the environments with unpredictable performance. As the regression coefficient exceeded unity for Local/Kokuso 13 Sl, AB/Kokuso 13, White Badana/Philippine and S54 they were found to be highly sensitive to environmental fluctuations. But they are more suitable to favourable environments compared to their performances under less favourable environments. As these genotypes were not stable when they were grown in different environments, their performances may not be predicted very easily. On the contrary genotypes Sujanpur-l/Philippine Sl, Local/Kokuso 13 S2, Mizusawa/Black cherry and M5 were found to be less sensitive to environmental fluctuations (bi=less than one) indicating their poor adaptability to all environments with unpredictable performances.

The environments influenced much for the expression of moisture content of leaves 24 hours after harvest as revealed by varied environmental indices and environmental means. The stability parameters regression coefficient was not significantly deviated from unity for all the genotypes. Whereas, the deviation from regression was found to be significant for only two genotypes viz., White Badana/Philippine, Mizusawa/Black cherry and other genotypes were found non significant. None of the genotypes was found to be stable for this character.

For genotypes viz., AB/Kokuso 13 and White Badana/philippine were found to be higly sensitive to environment as indicated by their regression coefficient exceeding unity. Thus this genotype is better suitable to favourable environments, but as they were not stable their performances cannot be predicted when grown in different environments.

Regression coefficient (b_1) was found to be less than one for Sujanpur-1/Philippine S1, Local/Kokuso 13 S2 and Mizusawa/Black cherry indicating their less sensitiveness to environment. Thus this genotypes were suitable to all environments but their performances will be very poor as indicated by low mean, their performances also cannot be predicted.

The genotyes, Mizusawa/Cattaneo, Sujanpur-1/Philippine S2 and Local/Kokuso 13 S1 with average and above average mean did not deviated from unit regression coefficient but they were deviated from mean square deviation (S^2d_i). Hence this genotypes were classified under average sensitive genotypes and are suitable to all environments.

Leaf to stem ratio by fresh weight

None of the genotypes were found to be stable as indicated by regression coefficient (b_i=1) and mean square deviation (S^2d_i=0). The genotypes Sujanpur-1/Philippine S1, Local/Kokuso 13 S2 and AB/Kokuso 13 were found to be higly sensitive to environmental fluctuations (bi more than one) indicating that better suitability to highly favourable environments. Since they were not found to be stable their performances may not be predicted when they grown in different environments.

Regression coefficient (b_1) was found to be less than unity for Mizusawa/Cattaneo, Mizusawa/Black cherry and in checks Mysore Local, M5 and S54 indicating their poor adoptability to all environments. but they were less sensitive to environment, their performances also cannot be predicted.

Internodal distance

For internodal distance all the genotypes found to be significantly deviated from regression coefficient (b_i=1) and mean square deviation (S^2d_i=0). No genotypes was found to be stable for this character. Cross Sujanpur-1/Philipine S2 and Mizusawa/Black cherry were highly sensitive to environmental fluctuations (b_i more than one) with high mean performances indicating its suitability to high yielding (more favourable) environment. As it was not stable its performance cannot be easily predicted when grown in different environments.

Low mean coupled with regression coefficient (b_1) less than one indicates White Badana/Kosen, Sujanpur-1/Philippine S1, Local/Kokuso 13 S1, Local/Kokuso 13 S2, AB/Kokuso 13, White Badana/Philippine and S54 were less sensitive to environmental fluctuations. Thus adopted to all environments and their perforamances over environments is unpredictable.

Chlorophyll content of leaves

For chlorophyll content 'a' two crosses viz., AB/Kokuso 13, Mizusawa/Black cherry and check Mysore Local were found to be stable as indicated by regression coefficient (b_i=1) and mean square deviation (S^2d_i=0). Genotypes M5, Local/Kokuso 13 S1 and Sujanpur-1/Philippine S1 were found to be highly sensitive to environmental fluctuations (b_i more than 1) with high mean performance indicating its suitability to high yielding (more favourable) environments. As they were not stable cannot be easily predicted when grown in different environments.

Low mean coupled with regression coefficient (b_1) less than one indicates Mizusawa/Cattaneo and S_{54} has got less sensitivity to environmental fluctuations. thus it was adapted to all environments and its performance over the environments is unpredictable.

Eventhough White Badana/Philippine was found to be less sensitive to environment its high mean performance indicates its better adaptability to widely differing conditions with unpredictable performances when grown in different environments.

The other genotypes White Badana/Kosen and Local/Kokuso 13 S2 were of average response to environmental variations indicating that they are suitable to all environments.

Stability parameters bi and s2di indicates White Badana/Kosen and Mizusawa/Black cherry were found to be stable for chlorophyll 'b' content over three environments. It also indicates that their performances can be predicted well over the environments studied.

The genotypes Local/Kokuso 13 S1, White Badana/Philippine and Mysore Local were found to be highly sensitive to environmental fluctuations as indicted by regression coefficient (bi is more than one) and mean square deviation (S^2d_i=0). It indicates their stability to more favourable environments with unpredictable performance when grown in different years. On the contrary Mizusawa/Cattaneo and Sujanpur-1/Philippine S2 were found to be less sensitive to environment with poor mean performance, which indicates their poor adaptability over all the environments studied.

The regression coefficient (b_1) was found to be equal to one in M5. Indicating its average sensitivity to environmental fluctuations. It may be suitable to all types of environments being studied. As they are not stable their performances cannot be easily predicted when grown over environments.

Among the 12 genotypes studied two crosses viz., White Badana/Kosen, Mizusawa/Black cherry observed to be stable for total chlorophyll content of leaves as indicated by regression coefficient (b_i=1) and mean square deviation (s^2d_i=0).

As per the stability parameters the regression coefficient exceeding unity for Sujanpur-1/Philippine S2, Local/Kokuso 13 S1 and White Badana/Philippine they were found to be highly sensitive to environmental fluctuations, but were more stable to favourable environments compared to their performances under less favourable environments. On the contrary genotypes Mizusawa/Cattaneo, Sujanpur-1 /Philippine S1, Local/Kokosu 13 S2, AB/Kokuso 13, and S54 were found to be less sensitive to environmental fluctuations (bi= less than one) indicating thier poor aduptability to all environments with unpredictable performance.

Crude protein content of leaves

As per the stability parameters genotype AB/Kokuso 13 was found to be stable for this character over three years as indicated by regression coefficient (b_i=1) and mean square deviation (S^2d_i=0) from regression.

The genotypes Sujanpur-1/Philippine S2, Local/Kokuso 13 S1, Local/Kokuso 13 S2, White Badana/Philippine, mizusawa/Black cherry and Mysore Local were found to be moderately sensitive to the environments (b_i=1). This indicates their suitability to all environments but due to instability their performances cannot be predicted when they grown in different environments.

Sujanpur-1/Philippine S1, M5 and S54 were found to be highly sensitive to the environmental variations and are more suitable for favourable environment compared to less favourable environments. However, their performance cannot be easily predicted.

Mizusawa/Cattaneo and White Badana/Kosen were found to be less sensitive to environmental variations (b_i= less than one). Possessing lesser mean values that exhibit their poor adaptability to all environments. However, the performances of these genotypes when grown in different environments cannot be easily predicted.

Stomatal frequency of leaves

Stability parameters regression coefficient (b_1) and mean square deviation (S^2d_i) indicates that S54 and Local/Kokuso 13 S1 as stable genotypes for stomatal number at lower surface of leaves.

Since regression coefficient (b_1) was equal to one in case of Local/Kokuso 13 S2 and Mizusawa/Black cherry they were found to be moderately sensitive to environments, indicating their suitability to all the environments under study. As these genotypes were not stable their performances cannot be easily predicted when they are grown in different environments.

Two genotypes viz., Mizusawa/Cattaneo and Sujanpur-1/philippine S1 were found to be highly sensitive to environmental fluctuations as indicated by stability parameters S^2d_i=0 and bi being more than one. They can be considered to be well suited to more favourable environments. However, when they are grown in different environments their performance may not be predicted easily. The genotypes White Badana/Kosen, AB/Kokuso 13, White Badana/Philippine, Mysore Local and M5 were found to be less sensitive to environmental fluctuations as indicated by stability parameters s2di=0 and bi is less than one. Less mean performance of these genotypes indicates their poor adaptability to all environments.

Among the genotypes only two genotypes viz., Mizusawa/Cattaneo, Sujanpur-1/Philippine S2 were found to be stable for stomatal frequency at upper surface of leaves.

Over three environments as indicated by regression coefficient (b_i=1) and mean square deviation (S^2d_i=0) from regression.

The genotype S54 has found to be moderately sensitive to environments (b_i=1), this indicates its suitability to all the environments. As it was not stable its performance cannot be predicted when it is grown in different environments.

Sujanpur-1/Philippine S1, and Local/Kokuso 13 S1 and Local/Kokuso 13 S2 were found to be highly sensitive to environmental variations and are more suitable for favourable environments compared to less favourable environments.

White Badana/Kosen, AB/Kokuso 13, White Badana/Philippine, Mizusawa/Black cherry, Mysore Local and M5 found to be less sensitive to environmental variations (b_i is less than one) possessing lesser mean value exhibits their poor adaptability to all environments. However, the performances of this genotypes when grown in different environments cannot be easily predicted.

It was evident from the statistical analysis that the genotypes differed significantly from environment to environment. However the response of genotypes to changing environment was not the same for all the characters. Environments differed among one another for all the characters indicating their existed inherent differences among the environments.

Kharif (E1) environment was conducive for majority of the characters followed by summer (E3) environment and rabi (E2) environment. Genotype X environment interactions which was highly significant for most of the characters ruled out any possibility of isolating a particular character with low magnitude of interaction.

The pooled deviation for most of the characters were high and not approaching zero indicating that the prediction cannot be valid. Further this also suggested that the contribution of non-linear component was more than linear component towards the interaction effects.

No single genotype was stable for all the characters, as revealed by the stability parameters for each character and each genotype. However, some strains were found to be stable for some characters. This suggests that stability for yield in a variety can be achieved by stabilizing some characters, and stability for one character is independent of stability for another character.

In respect of yield parameters cross Local/Kokuso 13 S2 was found to be stable for leaf yield over all the three seasons where as Sujanpur-1/Philippine S2 found stable for leaf area per plant over all the three environments.

SUMMARY

VI SUMMARY

Mulberry is a sole food source of silkworm *Bombyx mori* L. To develop an improved strain with higher yield that possesses good quality leaves through breeding programmes, evaluation of existing genetic variability in the germplasm by the application of biometrical methods is essential, so also production of new strains by hybridization.

Twelve clones of mulberry consisting of nine crosses and three checks were selected for the present investigation. The genotypes were studied in a Randomised Complete Block Design (RCBD) in three replications at the Agriculturl College, Hebbal, Bangalore-24 druing kharif, rabi and summer seasons of 1990 with an objective to study yield variability, heterosis and stability analysis in kharif, rabi and summer. Observations were recorded on five plants in each replication in each treatments, observations on leaf yield were recorded for three successive harvests at the interval of three months between each harvest. Significant difference between the clones were observed for all the characters studied.

Some of the crosses viz., Mizusawa/Cattaneo, Local/Kokuso 13 S1, Sujanpur-1/Philippine S1, Sujanpur-1/Philippine S2, and check variety S54 showed greater variability with respect to leaf yield.

Investigation on performance of hybrids against check varieties M5 and S54 were carried out with a view to measure the extent of standard heterosis. the magnitude of heterosis was measured for sixteen characters viz., plant height, number of leaves, number of branches, internodal distance, fresh and dry weight of leaves, fresh weight of stem, dry weight of stem, leaf to stem ratio, moisture percentage of leaves, chlorophyll content of leaves, crude protein content in leaves, stomatal frequency, total leaf weight per plant, leaf area per plant, leaf area index and total leaf dry matter yield per plant.

Significant positive standard heterosis was observed in hybrids Mizusawa/Cattaneo, Sujanpur-l/Philippine Sl, Sujanpur-l/Philippine S2, Local/Kokuso 13 Sl, over both check varieties for number of branches per plant. Local/Kokuso 13 S2 over M5 check and three hybrids over S54 check manifested significant positive standard heterosis for number of leaves per plant. Nine hybrids also showed significant positive standard heterosis for internodal distance over both the check varieties.

One hybrid over M5 and three hybrids over S54 manifested significant positive standard heterosis for fresh weight and dry weight of stem. The cross Local/Kokuso 13 S2 over both check varieties showed significant positive standard heterosis for leaf to stem ratio by fresh weight. With respect to chlorophyll ´a' content only one hybrid exhibited significant positive standard heterosis over S54 check. Whereas six hybrids showed significant positive standard heterosis over S54 for chlorophyll ´b' content and for the character total chlorophyll content three hybrids over S54 manifested significant positive standard heterosis.

Significant positive standard heterosis was observed for total leaf weight per plant over S54 check for three hybrids. Two hybrids over M5 and four hybrids over S54 exhibited significant positive standard heterosis for leaf area per plant. Leaf area index manifested significant positive standard heterosis with two hybrids over M5 check and three hybrids over S54 check. So also two hybrids over M5 and three hybrids with respect to S54 exhibited significant positive standard heterosis for total leaf dry matter yield per plant.

Positive standard heterosis was observed for three hybrids over two check varieties for fresh and dry weight of leaves. Moisture content of leaves also exhibited positive standard heterosis with three hybrids over both check varieties. Two hybrids for crude protein content showed positive standard heterosis over M5, so also positive standard heterosis was observed for the character total leaf weight per plant with three hybrids over M5 check.

Three hybrids manifested negative standard heterosis over both check varieties for stomatal frequency on lower surface of leaves. whereas six hybrids manifested negative standard heterosis with one hybrid over M5 and three hybrids over S54 with respect to character stomatal frequency on upper suraface of leaves.

For leaf yield, hybrids viz., Mizusawa/Cattaneo, Sujanpur-l/Philippine Sl and Local/Kokuso 13 Sl surpased the Local variety M5 whereas hybrids viz., Mizusawa/Cattaneo, Sujanpur-l/Philippine Sl and Local/Kokuso 13 Sl were significantly superior over S54 check. It is evidient that hybrid production for this character would definitely increase the production of yield. Similarly for quality parameters hybrids viz., Mizusawa/Cattaneo, Local/Kokuso 13 Sl, Local/Kokuso 13 S2, AB/Kokuso 13, White Badana/Philippine and Mizusawa/Black cherry were superior over M5 check, whereas AB/Kokuso 13 and White Badana/Philippine surpased S54 for moisture content of leaves. For total chlorophyll content of leaves, hybrids White Badana/Philippine over M5 where as all the hybrids except Local/Kokuso 13 S2 over S54 showed higher chlorophyll content. Lastly hybrids Sujanpur-l/Philippine Sl, AB/Kokuso 13 were superior over M5 check with respect to crude protein content of leaves.

Two way analysis of variance revealed that the genotypes and environments differed significantly for all the characters under study. This also suggested the existence of significant genotype X environment (GE) interactions in respect of all the characters studied.

The genotypes differed in their response to varying environments for majority of the characters as indicated by the stability analysis done as per the model proposed by Eberhart and Russell (1966). Environment (linear) was significant for most of the charcters, while genotype X environment (linear) was found significant for plant height, leaf to stem ratio by fresh weight, internodal distance, chlorophyll ´b' content, total chlorophyll content and stomatal frequency on both lower and upper surface of leaves. Pooled deviation on the other hand was highly significant to most of the characters indicating that prediction portion for the major part of the G X E interaction.

Stability parameters were computed for each character and for all genotypes adopting the methods outlined by Eberhart and Russell (1966). None of the genotypes was stable for all the characters. Stability for one character was independent of the others.

Based on stability parameters and overall performances the genotypes Local/Kokuso 13 S2 was found to be stable for leaf yield and Sujanpur-1/Philippine S2 found stable for leaf area per plant over all the three environments. For leaf quality parameters like moisture content of leaves, crude protein content and chlorophyll content of leaves genotypes Local/Kokuso 13 S2, Mysore Local and M5 (for moisture content), AB/Kokuso 13 (for crude protein content), White Badana/Kosen and Mizusawa/Black cherry (for chlorophyll content) were found stable for all the three environments under study.

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Original not seen

APPENDIX

APPENDIX

Weather data prevailing at Main Research Station, Hebbal, Bangalore-24

Months	Total Rainfall (mm)	Mean temperature Max.	Mean temperature Min.	Mean Relative humidity (%) at 7.20 hr	Mean Relative humidity (%) at 14.20 hr
Year 1990					
June	29.7	30.20	20.10	93.0	57.0
July	17.7	29.10	19.50	95.0	59.0
August	69.4	27.7	19.70	95.0	68.0
September	72.7	31.3	19.90	90.0	56.0
October	53.7	28.3	19.50	92.0	62.0
November	16.4	27.1	17.40	94.0	57.0
December	5.0	26.7	15.60	95.0	51.0
Year 1991					
January	0.0	28.9	15.70	95.0	42.0
February	0.0	30.7	15.50	89.0	34.0
March	0.0	33.3	19.90	79.0	29.0
April	73.2	32.6	21.40	84.0	35.0
May	88.0	34.1	21.80	83.0	42.0