ADAPTABILITY AND PATH ANALYSIS IN BERSEEM (*Trifolium alexandrinum* L.)

By

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(Regd. No. 94023)

A Thesis Submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,

RAHURI - 413 722 DIST.-AHMEDNAGAR

Maharashtra State (India)

In partial fulfilment of the requirements for the degree

of

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in

CYTOGENETICS AND PLANT BREEDING

DEPARTMENT OF BOTANY

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MAHATMA PHULE KRISHI VIDYAPEETH,

RAHURI, DIST. AHMEDNAGAR, M. S. (INDIA.)

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CYTOGENETICS AND PLANT BREEDING

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1997

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or other person to any other University or Institute for a Degree or Diploma.

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CERTIFICATE

This is to certify that the thesis entitled, "**ADAPTABILITY AND PATH ANALYSIS IN BERSEEM (*Trifolium alexandrinum* L.)**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for a degree of **MASTER OF SCIENCE (AGRICULTURE)** *in* **CYTOGENETICS AND PLANT BREEDING**, embodies the results of a piece of bona fide research work carried out by **Shri. DATTATRAYA V. KUSALKAR** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been acknowledged.

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Place : MPKV, Rahuri.

Dated : 4 / 7 /1997.

(D.V. KUSALKAR)

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LIST OF ABBREVIATIONS

Abbreviation	Description
cm	Centimeter(s)
g	Gram(s)
L/S ratio	Leaf stem ratio
Fig.	Figure
s.s.	Sum of square
m.s.s.	Mean sum of squares
S.E.	Standard error
i.e.	that is
df	degrees of freedom
et al.	and others
ha	hectare
kg	Kilogram
%	Per cent
/	per

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ABSTRACT

ADAPTABILITY AND PATH ANALYSIS IN BERSEEM (*Trifolium alexandrinum* L.)

By

DATTATRAYA VITHOBA KUSALKAR

A candidate for the degree of

MASTER OF SCIENCE (AGRICULTURE)

MAHATMA PHULE KRISHI VIDYAPEETH
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1997

Research Guide	:	**Dr. F.B. Patil**
Department	:	**Agricultural Botany**
Major Field	:	**Cytogenetics and Plant Breeding**

Investigations were conducted for critical assessment of adaptability, associations and path effects in berseem. Twenty genotypes including two check varieties (Wardan and Mescavi) were evaluated at Rahuri, Maharashtra in three predictable environments (E_1, E_2, E_3) during *Rabi*, 1994-95 and three cuts were taken in each environment.

Plant height, number of tillers per plant and per meter length, L/S ratio, green and dry fodder yield per plant, crude protein content and green fodder yield per meter distance were studied. Significant G x E interactions were observed for all the characters studied in all the environments. Importance of linear component of G x E interaction was observed in the expression of plant height (in E_1, E_2 and over all environments), number of tillers per plant (in E_1), number of tillers per meter length (in E_2, E_3 and over all environments), green fodder yield (in E_1, E_2 and over all environments), dry fodder yield per plant (in all environments) and green fodder yield per meter distance (in E_1, E_3 and over all environments). Pooled deviation (non-linear) effects were highly significant for all the characters except number of tillers per plant in E_1 environment.

The genotypes viz., JHB-93-3 (plant height), JHB-92-2 (number of tillers/plant, crude protein content), JHB-93-4, HFB-135, Wardan and Mescavi (number of tillers/plant) had wider adability in nine environments (i.e. over all environments). Further, the genotypes viz., JHB-92-2, HFB-135, Mescavi in all the three predictable environments (E_1, E_2 and E_3) were stable for most of the characters including green and dry fodder yield per plant.

The genotypes, BL-126 for number of tillers per plant, Mescavi for L/S ratio, BL-122 and JHB-93-2 for green fodder yield per plant in E_2 environment, While, the genotype BL-126 for number of tillers per meter distance, JHB-93-4 for green and dry fodder yield per plant and protein content and Wardan for dry fodder yield and crude protein content in E_3 environment appeared adapted to rich environment (i.e. with below average stability), Whereas, the genotypes,BL-130 for green forage yield and BL-102 for L/S ratio in E_2 and E_3 environments, respectively were adaptated to poor environment having above average stability.

The correlation studies indicated the importance of all the characters except L/S ratio as they were significantly associated with green fodder yield per meter distance in all the three predictable environments. However, considering direct and indirect effects under various environments, the components such as plant height, crude protein content, number of tillers per plant and green fodder yield per plant appeared most important in the selection criteria aiming at improvement in fodder yield of berseem.

Introduction

1. INTRODUCTION

Forage is a specific term which includes cultivated forage crops, specially grown grasses, legumes, bushes, grasslands and pasture herbage, crop residues, hay and silage. It is the basic raw material of livestock industry of all kinds. The importance of these crops in the growth and development of agriculture including resource conservation, improvement in soil fertility, soil and water conservation, improving ecological balance and the vital role in the livestock industries needs no description.

The livestock population in the state of Maharashtra is 2.96 crores (excluding poultry) which derives its fodder/feed from following resources :

1. The crop residues.
2. The grass land herbage inclusive of bund grasses, tree leaves, miscellaneous grasses from waste lands and fallow lands.
3. Cultivated forage crops.

The total dry matter requirement of this livestock in the state is around 7.65 crore metric tonnes per year, but the availability from all the fodder resources, is about 5.03 crore metric tonnes per year. It means we can supply only about 65.70 per cent of the total fodder requirement for servival thus leaving shortage of about 34.30 per cent (Anonymous, 1993).

The situation stated above suggests the necessity to increase forage production. The area under cultivated forage is less than 5 per cent of total cultivated area, however, they contribute about 37 per cent the total forage production. Hence, it is necessary to breed improved varieties, of important forage crops like lucerne, berseem, oats, maize, sorghum, bajra, etc., having stability in performance over locations, seasons or environments.

In India, the scarcity of green fodder is one of the most important limiting factors for achieving white revolution. Berseem which is also called Egyption clover (Trifolium alexandrinum L.) is believed to be native of Asia Minor. Berseem is belived to be indigenous to Egypt (Narayanan and Dabadghao, 1972). It is also cultivated in Syria and Persia, where it forms the principal green forage for horses, donkeys and camels. Significance of this forage species lies in development of milk industry. It appeared to behave as the most potent milk multiplier in the lactating baffaloes, sahiwal cows and crossbred cattle as compared to other forage crops, alone or in combination with other (Patil, 1982).

Berseem belongs to family Leguminosae and the genus Trifolium. The genus Trifolium Tourn (L.) has nearly 290 temperate and sub-tropical species. The chief species of clovers for forage and pasture are Egyptian clover (Trifolium alexandrinum L.), Shaftal (T. resupinatum L.), white clover

(*T. repens* L.), red clover (*T. protense* L.) crimson clover (*T. incarnatum* L.), abike clover (*T. hybridum* L.) and subterraneam clover (*T. subtenaneum* L.), *Trifolium alexandrinum* L. indicates diploid chromosome number with 2n=16 (Mokhtarzadeh and Constantin, 1978).

In Maharashtra, the dairy farmers are showing interest to grow berseem for forage production under irrigated conditions. The high yielding and cross bred cows need regular supply of green and nutritious forage through out the year to maintain their potential of milk production. Moreover, availability of green forage in *rabi*, is a problem. Therefore, it is possible to compensate the fodder deficit with limited sources of irrigation by growing the crop like berseem in *rabi*. More over, among the *rabi* sole forage legumes, berseem is second important next to lucerne. It gives higher nutritious fodder than lucerne within the unit time, which can be fed as green as well as in the form of hay. It also serves as a good rotation saving 25 to 50 per cent of nitrogen application to the following crop. Hence, berseen needs to be popularised for its cultivation on large scale in Maharashtra.

There is good scope to improve the productivity of this crop by varietal improvement and management paractices. The knowledge of association between characters, their direct and indirect effects on yield and about in genotype x envioronment is important in formulating more efficient breeding programmes for better response to selection in biological population.

The ability of individual population or species to change in the form or function in such a way to better survive under given environmental conditions is termed as adaptability (Allard, 1960). Genotypes possessing this ability do well in different environments and are said to be generally adaptable. Some genotypes do well only under certain set of environmental conditions, such as poor or rich environments, which are said to have specific adaptability. Thus, the predictability of performance i.e. stability depends upon the adaptability of the genotypes. Stability in the yield and its components is therefore, one of the most desirable characters for the adaptability of the genotypes.

The present study entitled 'Adaptability and path analysis in berseem' was therefore, planned with the following objectives :

1. To detect the Genotype x Environment interaction for forage yield and its components.
2. To identify various genotypes having general (wider) adaptability over cuts/showing dates (time) and fertilizer levels.
3. To identify the genotypes having specific adaptability for sowing time and fertilizer levels.
4. To know the relationship among various components of forage yield.
5. To study direct and indirect contribution of the components to forage yield.

Review of Literature

2. REVIEW OF LITERATURE

The literature relevant to present investigation is included in this chapter.

2.1 Origin and distribution

Egyptian clover (*Trifolium alexandrinum* L.) popularly known as berseem is the most important *rabi* fodder crop for irrigated areas of Northern India. The centre of origin of berseem is Egypt (Narayanan and Dabadghao, 1972). Berseem is derivative of an Arabic name `Bersym' or `Berzum' meaning have proved their worth in India.

Intercontinental introductions have been found to be successful in clovers. Italian introductions of Egyptian clover were found to be most suitable in Russian conditions (Simon, 1969).

Studies for chromosome number in the cells of root tips from callus regenerated from hypocotyle and other explants of *Trifolium alexandrinum* indicated diploid chromosome number to be 2n = 16 (Mokhtarzadeh and Constantin, 1978).

Trifolium alexandrinum are self compatible. Chiasma frequency varied between species and ecotypes within the range of 10.8 to 16.1 per cell (Khushk and Abidi, 1970).

Berseem is an annual shrub. The stem is succulent but becomes fibrous after flowering. Leaves are tri-foliate. Leaflets are small, oblong bright green and slightly hairy. Flower heads are round and white. Pod oblong with one to two seeds.

2.2 Stability

2.2.1 Concept

Plant breeders exert maximum on available variability in crop plants and attempt to select the best adapted types response to which depends upon the recombinational variability. This variability differs from crop to crop depending also on the mating system. In cross pollinated crops, the variability is maintained in heterozygous condition, while in homozygous phase with small percentage of heterozygotes which are formed through occasional mating among homozygous populations. Locally adapted variability is the primary material of adaptability and is augmented for new and alien gene combinations which tend to be less adapted unitl incorporated into local types (Simmonds, 1962). Thus, variability which is of prime importance to the plant breeder, depends upon the mating system and evolutionary history of crop species.

A basic knowledge of the crop variation between environments or seasons is essential in evaluating the available genetic material. In recent years, stability analysis has became one of the important tools for such type of studies.

Mather (1949) provided the biometrcal approach to work out additive, dominance and epistitic gene actions and genotype x environment interactions. Partitioning of variety x location interaction (6^2ge) for each variety was also discussed by Plaisted and Peterson (1959). A variety was considered more stable which contributed least towards (6^2ge).

Lewis (1954) introduced stability factor to measure the phenotypic stability.

Jones (1958) attributed stability to the homeostatic effect of genetic heterogeneity and suggested that such stability permits double crosses to produce high yields over many years. Even though the highest yield at any one place is likely to be obtained from specific single crosses.

Plaisted and Peterson (1959) developed a method to characterize the stability in yield performance. When several varieties were tested at a number of locations within one year, a combined analysis of variance overall locations was computed for each pair of varieties (n (n-1)/2 pairs for 'n' varieties) and an estimate of σ^2v was obtained for each variety. The variety with the smallest mean value would be one that contributes the least to variety x location interaction and thus, would be considered as the most 'stable' genotype in the test.

Finlay and Wilkinson (1963) utilized the regression technique to compare the performance of a set of cultivars grown at many sites. For each variety, varietal mean yields over environments and regression coefficients were estimated and used to classify the cultivars specially adapted to poor or better yielding environments and or for general adaptability. They have indicated average phenotypic stability by a regression coefficient of unity (b=1.0). A cultivar with b < 1.0 has above average stability while these with b > 1.0 has below average stability and b=0 has absolute phenotypic stability which means a similar magnitude of grain yield in all the environments. The ideal cultivar is one that possesses genetic potential in the highest yielding environment and maximum phenotypic stability.

Eberhart and Russell (1966) observed that corn hybrids with a regression coefficient less than 1.00 usually had mean yields that were below average. Accordingly, they suggested that a desired variety should have high mean, regression coefficient equal to 1.0 and variance due to regression as small as possible. Thus, they modified the regression technique which enables partitioning of the genotype x environment interaction of each variety into two parts, (i) the variation due to the response(bi), of the variety to varying environmental indices (sum of squares due to regression) and (ii) the unexplainable deviation from the regression on the environmental index. They defined both the linear (bi) and non linear (S^2di) components as stability parameters. They compared two types of crosses in maize. They reported that the hybrid x year interactions were significantly greater for single cross than for three way crosses.

The approaches of Finlay and Wilkinson (1963) and Eberbart and Russell (1966) are purely statistical and components of these analysis have not been related to parameters in biometrical genetic model. Perkins and Jinks (1968) performed the second approach which was based on fitting of models, which specify the contribution of genetic, environmental and genotype x environment interaction to the generation means and variances allowing for the contribution of additive, dominance and epistatic gene effects to the genetic and interaction components.

The mode used by Perkins and Jinks (1968).

$$Y_{ijk} = \mu + d_i + \Sigma_j + r_{jk} + B_iE_j + d_{ij} + e_{ijk}$$

The interpretation of stability parameters is not different from that of Eberhart and Russell (1966). In this model 'Bi' is equal to '1-bi'.. Hence 'bi' is tested for its deviation from unity and 'Bi' from zero.

Freeman and Perkins (1971) proposed independant estimate of environmental index in two ways, (i) Divide the replications in to two groups, so that the one group can be used for measuring the average performance of varieties in various environments and the other group averaging over the varieties is used for estimating the environmental index (ii) or use one or more varieties as check and assess the environmental index on the basis of their performance. They proposed the following model.

$$Y_{ijk} = m + d_i + e_j + g_{ij} + e_{ijk}$$

Tai (1971) presented a method of genotypic stability based on principal structural relationship analysis, where a genotype x environment interaction of a particular variety is partitioned into two components viz., the linear response to environmental effects `X' and a deviation from the lines `r' response (X). The mathematical model used was

$$Y_{ijk} = \mu + g_i + I_j + (gI)_{ij} + b_{jk} + e_{ijk}$$

Where, `g' genotypes are tested over `n' environments with `r' replications under each environment.

Bains and Gupta (1972) proposed that if the linear regression of the above average genotypes upon the environmental means is less than 1.0 with comparatively small deviation mean square an agreeable compromise between the two definations of Finlay and Wilkinson (1963) and Eberhart and Russell (1966) is essential.

Kellog et al. (1976) grouped stability statistics into four groups depending upon whether they are based on the deviations from the average genotype stable if.

1. its among environment variance is small

2. if its response to environments is parallel to the mean response of all genotypes in the trial or
3. if the residual mean square from a regression model on the environmental index is small.

2.2.2 Stability in berseen: effect of varied environments

Ganguly and Relwani (1961) reported effect of fertilizer on the yield of paddy and berseem in paddy berseem rotation.

Taneja et al. (1987) showed that sowing of berseem crop for seed production could be delayed upto middle of November without any adverse effect on its seed yield. While, delay in sowing caused reduction in forage yield significantly. Application of nitrogen to berseem crop could neither influence the seed yield nor the forage yield, whereas, application of 80 kg P_2O_5/ha enhanced the seed yield as well as forage yield significantly over the lower dose.

Kheiralla et al. (1988) studied performance and genotypic stability for fresh forage yield, dry matter and protein content and ash of 36 accessions of Trifolium alexandrium at 3 locations, ten and twelve genotypes exceeded the control variety, Mescavi in forage yield and dry matter per cut, respectively but only two accessions surpassed Mescavi in dry matter per cent and ash content.

Kharb et al. (1986) evaluated thirteen Trifolium alexandrinum genotypes in 5 environments for forage yield. There was significant G x E interaction.

Ashraf (1989) reported salt tolerance of 10 Trifolium alexandrinum cultivars assessed in sand culture with 0, 75, 150 or 225 mol NaCl/m^3. Dry weight of plants harvested 5 weeks after the start of salt treatments, just before the flowering, decreased with increasing salinity in all cultivars.

Khatri and Jatasra (1991) assesed 24 genotypes of berseem including 3 checks viz., Mescavi, BL-1 and Wardan in randomised block design at Hisar during rabi, 1985 to 1987 to study the stability for green and dry fodder yields of these genotypes. In general, linear portion of G x E was higher than non linear. Genotypes, HFB-112, HFB-114 and HFB-91 were specifically superior.

Rana et al. (1992) conducted a field experiment comprising four sowing dates (25 Oct., 9, 24 Nov. and 9 Dec.), three seed rates (15, 25 and 35 kg/ha) and three phosphorus levels (0, 40 and 80 kg P_2O_5/ha) at Haryana Agril. University, Hisar during rabi season of 1982-83 and 1983-84. The crop sown on 25th October, recorded significantly higher green as well as dry fodder yield.

Khatri et al. (1992) studied phenotypic stability of 24 berseem genotypes including three checks viz., Mescavi, BL-1 and wardan. The stability analysis revealed that both linear and non-linear components of G x E interaction were present for both green and dry fodder yield. However, the magnitude of linear portion was higher than that of non-linear for both the fodder traits. Genotypes, HFB-91 and HFB-112 yielded higher but were unstable for both green as well as dry matter yield at both the locations. Genotypes, HFB-468 to 472, HFBS-474, 475, 477, 478, 481, 484 and Wardan were characterised as having average response and were also stable for dry matter yield.

2.2.3 Stability and effect of environments in related crop like lucerne

Cowett and Sprague (1962) found that increasing stand density of Alfalfa from 1 to 8 plants per square foot decreased number of tillers and dry weight per plant although yield per acre increased.

Kellog _et al_. (1976) reported significant differences for crude protein content of five lucerne clones studied at two cutting dates. General combining effects for crude protein were significant.

Rai and Singh (1976) studied ten introduced and local varieties cut five times. Indian Muller farm gave the highest fresh fodder and dry matter yields followed by Sonora certified under E_1. Crude protein content in the dry matter was highest in AS-13 and GWL-501.

Arcioni and Mariani (1979) compared Italian and Umbarian varieties and found Turrena to have good persistence and further compared with Casalina, an early promising variety and reported Casalina as better material for green and dry matter content, regrowth rate and protein content.

Sanghi and Raj (1983) studied phenotypic stability in 17 cuts and observed that cultivar Anand-7 was above average in performance for fresh forage and dry matter yields and plant height, below average in response and stable for leafiness but was unstable for number of tillers. The standard cultivar T-9 was very poor in performance, below average in response but stable for yield only.

Belzile (1984) reported the effect of sowing date and seedrate on the height, and yield of Lucerne. Effects of cultivar on quality were veriable and seed rates had no effect. Variation in forage yields may be attributed to a difference in plant maturity at harvest.

Lutz et al. (1985) did not abserve sighificant differences in dry matter production between 4 native cultivars of alfalfa and the best introduced ones but all produced significantly more than the standard.

Chlaupek et al. (1987) conducted trials for yield and stability in synthetic lucerne populations viz., ZE-S IV and ZE-S-V, using Palava as a standard and observed more or less similar performance of both the synthetics, exceeding Palava in green matter yield by 1-2 per cent and also exceeded in green matter yield at increasing age (upto 4 years) indicating greater persistance and stability. Also their nutritional quality and palatability were good.

Volenec et al. (1987) reported that yield components were affected by plant density and high yield per tiller increased the yield in lucerne.

Patel et al. (1987) studied different genotypes of lucerne. Anand-2, T-9, T-9 (Mass selection), Ativ LL, Comp-33 and SS-627 were sown during last week of oct, second week of Nov., last week of Nov., and second week of Dec. in first experiment while in second experiment the same genotypes were tested at different seed rates (10, 15, 20, 25 and 30 kg seed/ha). Anand-2 and SS-627 perfomed well in agroclimatic conditions of Gujrath state.

Pesek et al. (1988) studied yield stability in 17 lucerne verieries over 18 years and observed 14 per cent increase in hay yield, while hay yield stability was improved by 10 per cent.

Dahiphale et al. (1991) in a field trial conducted in rabi seasons of 1988-95 studied the green and dry fodder yields of Medicage sativa Cv. T-9, Anand-2, Atir, SS-627, LL-Comp-2, LL-Comp-5, Ahmednagar Local, FS-85 and Chikalthana local. Average annual dry forage yields ranged from 23.44 tones per ha in Chikalthana local to 28.27 tones per ha in T-9.

2.3 Correlation and path coefficient analysis

Correlation between dependent and independent characters and direct and indirect effects of independent characters on the dependent variables are completely desperate things. Sometimes the correlation between two characters may be highly positive, but the direct effect of the independent character on the dependent may be negative. Hence, meare correlation cannot serve the purpose of selection in plant breeding. In a complex situation selection for an optimum advance should be based on judiciously computed index.

Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. This was originally suggested by Wright (1921), discussed by Li (1955) and used by Durate and Adams (1972). De Way and Lu (1959) gave the detailed procedure for path analysis of replicated trials which was quite a different technique in eliminating the total variance and reported correlation and path coefficient analysis of components of creasted wheat grass seed production.

(a) Berseem

Habib *et al*. (1971) reported forage yield per plant closely correlated with the yield of leaves or stems, number of leaves and plant height in berseem. Correlation coefficients of lower magnitude were found between forage yield and either internode number or stem diameter. Seed yields were not closely associated with forage yield.

Jatasra *et al*. (1980a) reported positively significant correlation of plant height, tillers per plant and stem girth with green fodder yield of berseem. Path analysis showed plant height, tillers per plant and stem girth as the major component traits of green fodder yield. They advocated selection of these characters to bring improvement in berseem fodder yield.

Jatasra (1981) studied the correlation and path coefficients between green and dry matter yield and their nine components were studied both at the genotypic and phenotypic levels using 21 strains of Egyptian clover. Green fodder yield was positively associated with all traits investigated except leaf/stem ratio, stem girth and tillering. Dry matter yield showed positive relationship with green fodder yield and stem weight, leaf weight, plant height and leaf width. Path coefficient analysis further revealed that the direct effect of stem characteristics (stem girth, stem weight leaf/stem ratio) was positive only on green fodder yield, whereas, their direct effects on dry matter yield were negative.

Bakheit (1986) studied genetic variability, genotypic and phenotypic correlations and path coefficient analysis in fifty four accessions of Egyptian clover over four cuts at one locality in the 3 years 1981-84 and at a second locality in 1982-83. There were significant differences among accessions for the 6 characters and the accessions x environment interaction was significant for height, seasonal fresh yield per unit area, seasonal dry yield per unit area and seasonal protein yield per unit area.

Shukla et al. (1987) studied correlation and path coefficients with green forage yield per plant and four related traits from 20 Trifolium alexandrinum germplasm accessions after 2 consecutive harvests which revealed that.

1. Leaf weight and number and stem weight were positively correlated with GFY and
2. Leaf and stem weight were the most important traits for improving GFY.

(b) Lucerne

Jatasra et al. (1980b) studied correlation and path coefficients between green fodder and dry matter yield and their components and also some quality characters of 30 lucerne genotypes. Among component characters, almost all were positively and highly associated with both green and dry matter yield at genotypic level. However, no relationship was obtained between green fodder and dry matter on one hand and quality traits on the other.

Plhak and Chlaupek (1988) observed in lucerne that protein, ash and dry matter content were positively correlated with each other but negatively with fodder yield and observed higher variation in protein content of stem 8 per cent than 3 per cent variation in leaves. The leaf/stem ratio being negatively correlated with fodder yield.

Shukla (1990) studied genetic variablity, correlation and path effects in Egyptian clover under two spacings, normal (25 x 10 cm) and wide (50 x 15 cm). Variability was noted for plant height, number of leaves, leaf weight, stem weight and green forage yield under both the spacings. Genotypic coefficients of variation were moderate to low for all the characters except leaf : stem ratio which showed positive correlation with green forage yield. Path analysis indicated leaf weight as the most important trait exerting the greatest direct effect on green forage yield under both spacings.

Material and Methods

3. MATERIAL AND METHODS

The present investigation on "Adaptability and path analysis in berseem" envisaged the study of on genotype x environment interaction, stability parameters and direct and indirect contribution of the components to forage yield.

The details of the material used, methods adopted and statistical analysis followed, during the course of this investigation are discribed below.

3.1 Experimental material

The material for the present study included twenty different promising genotypes of berseem (Table 1).

Table 1 : The berseem genotypes evaluated alongwith their origin/source

Sr. No.	Name	Origin
1.	BL-102	Ludhiana
2.	BL-122	Ludhiana
3.	BL-126	Ludhiana
4.	BL-130	Ludhiana
5.	BL-131	Ludhiana
6.	JB-90-2-56	Jabalpur
7.	JB-92-1	Jabalpur
8.	JHB-92-2	Jhansi
9.	JHB-93-2	Jhansi
10.	JHB-93-3	Jhansi

Table 1 contd...

Sr. No.	Name	Origin
11.	JHB-93-4	Jhansi
12.	JHB-146	Jhansi
13.	HFB-135	Hissar
14.	RMBS-93-0-1	Rahuri
15.	RMBS-93-0-2	Rahuri
16.	RMBS-93-0-3	Rahuri
17.	RMBS-93-3	Rahuri
18.	RMBS-93-5-2	Rahuri
19.	Wardan (c)	Delhi
20.	Mescavi (c)	Delhi

3.2 Experimental design

For the analysis of adaptability and path analysis, the separate experiments with twenty genotypes were conducted with following three environments, at Post Graduate Farm, MPKV, Rahuri (M.S.) in Randomised Block Design with three replications during Rabi 1994-95.

1. E_1 : Sowing in first week of December with 20 kg N + 80 kg P_2O_5/ha (F_1) as a basal dose.
2. E_2 : Sowing in first week of December with 30 kg N + 120 kg P_2O_5/ha (F_2) as a basal dose.
3. E_3 : Sowing in last week of December with 20 kg N + 80 kg P_2O_5/ha as a basal dose plus 10 kg N + 40 kg P_2O_5/ha after the first cut. Each genotype was represented by five rows (spaced 25 cm apart) with

the gross and net plot size of 1.25 x 3.0 m^2 and 0.75 x 2.50 m^2, respectively. Three cuts were completed under each treatment, till April, 1995.

3.3 Cultural practices

The land selected for the experiment was medium black. Fertilizer doses were applied as indicated under the above three environments.

3.4 Observations recorded for stability

The data on following characters were recorded on five randomly selected plants in each treatment and in each replication at each cut in all the three environments, except the characters at serial number 3.4.3 and 3.4.8 which were recorded on plot basis.

3.4.1 Plant height at every cut (cm)

The height of 5 tillers on randomly selected 5 tillers each of five randomly selected plants at every cut was recorded at the time of harvest and the average over 5 plants represented the plant height.

3.4.2 Number of tillers per plant

Number of tillers of five selected plants were recorded and mean number of tillers per plant was computed.

3.4.3 Number of tillers per meter row length

The number of tillers present in 1 meter row length was counted.

3.4.4 Leaf:stem ratio (L/S)

The leaf to stem ratio was calculated from the average weight of leaves and stems obtained from randomly selected five plants.

3.4.5 Green forage yield per plant (g)

Green forage yield of randomly selected five plants was recorded and average was worked out.

3.4.6 Dry forage yield per plant (g)

The weight of dry forage of all randomly selected five plants was recorded and average was worked out.

3.4.7 Crude protein content (%)

The crude protein content was estimated by the method of A.O.A.C. (Anonymous, 1970) separately for each cut and each environment.

3.4.8 Green forage yield per meter distance (g)

Green forage yield of plants from one meter length of a row selected at random was recorded.

3.5 Stability methodology

G x E interaction and stability parameters for twenty genotypes were estimated as per the method of Eberhart and Russell (1966). The data of three environments viz., E_1, E_2 and E_3 recorded were used for this purpose. The stability parameters of each set (environments) and also pooled over 9 environments were estimated separately.

3.5.1 Eberhart and Russell model

For each genotype stability was described by three parameters, which include (i) mean performance, (ii) the regression from the mean performance on environmental index (bi) and (iii) the function of squared deviation from this regression (S^2di). These parameters are defined with the model.

$$Y_{ij} = m + b_i I_j + d^2{}_{ij}$$

Where,

Y_{ij} = Mean of ith genotype in jth environment

m = Mean of all genotypes over all the environments

b_i = The regression coefficient of ith genotypes on the environment index, which measures the response of genotype to varying environments.

I_j = The environmental index which is defined as the deviation of the mean of all the genotypes at a given location from over all mean.

d_{ij} = The deviation from regression of the ith variety at jth environment.

3.5.1.1 Estimation of stability parameters

(a) The regression coefficient (bi) is described as under :

$$b_i = \sum_j Y_{ij} I_j \; / \; \sum_j I^2{}_j$$

Where,

$\sum_j Y_{ij} I_j$ = is the sum of products and

$\sum_j I^2{}_j$ = is the sum of squares of environmental indices

(b) Mean square deviation (S^2di) from linear regression is calculated as

$$\frac{\sum_j d_{ij}}{(S - 2)} - \frac{S^2e}{r}$$

Where,

$$\sum_j d^2_{ij} = \left[\sum_j Y^2_{ij} - \frac{Y^2_i}{t}\right] - \frac{(\sum_j Y^2_{ij}.I_j)^2}{\sum_j I^2_j}$$

and

Se^2 = The estimate of pooled error

t = Number of genotypes and

s = Number of seasons (environments)

The various computational steps involved in the estimation are as follows :

3.5.1.2 Computation of environmental index (I_j) We know that I_j is defined as

$$I_j = \frac{\sum_j Y_{ij}}{t} - \frac{\sum_i \sum_j Y_{ij}}{ts}$$

$$= \frac{\text{Total of all the varieties at jth location}}{\text{Number of varieties}} - \frac{\text{Grant total}}{\text{Total number of observations}}$$

3.5.1.3 Computation of regression coefficient (bi) for each genotype

$$b_i = \frac{\sum_j Y_{ij}.I_j}{\sum_j I^2_j}$$

Note :

1. For each value of regression coefficient $\sum_j I^2j$ is common and equal to sum of squares of environmental index.

   $\sum_j I^2j = (I^2{}_1 + I^2{}_2 + \ldots\ldots\ldots I^2{}_j)$

2. The $Y_{ij}.I_j$ of each variety is the sum of product of environmental index (I_j) with the corresponding mean $(\bar{x})$ of that genotype at each location. These values may obtained in following manner.

   $$\left[(\bar{X})\right]\left[(I_j)\right] = \left[(\sum_j Y_{ij}.I_j)\right] = (S)$$

   Where,

   $(\bar{X})$ = Matrix of the means

   (I_j) = Vector for environmental index

   (S) = Vector for sum of products i.e. $\sum_j Y_{ij}.I_j$

3. The 'b_i' value for each variety was thus, calculated by dividing $\sum_j Y_{ij}.I_j$ (as calculated above in ii) by $\sum_j I^2j$ (obtained above under i).

   Thus, $b_i = \sum_j Y_{ij}.I_j \;/\; \sum_j I^2j$

3.5.1.4 **Computation of S^2di**

In a regression analysis, it is possible to partition the variance of the dependent variable (Y) into two parts, the one which explains the linearity between dependent and independent variables (variance due to regression) and the other which explains the variance due to deviations from linearity.

Symbolically :

$\sigma^2 Y = \sigma^2$ regression + σ^2 deviation from the regression

By substracting the variance due to regression from $\sigma^2 Y$, one can get variance due to deviation from regression which in turn can be used for estimating S^2di values. The variance of means over different environment was obtained as follow.

$$\sigma^2 vi = \sum_j Y^2ij - (Y^2i/S)$$

Where,

$\sum_j Y_{ij}$ = Sum of square of mean of ith genotype over environments

Y_{ij} = Sum of mean of ith variety over environments (seasons)

The variance due to deviations from regression ($\sum_j d^2_{ij}$) for a variety being :

$$\sum_j d^2_{ij} = \sum_j Y^2ij - \frac{Y^2i}{t} - \frac{(\sum_j Y_{ij}.I_j)^2}{\sum_j I^2_j}$$

Where,

$\sum_j Y^2ij - \frac{Y^2i}{t}$ = The variance due to dependent variable

$\frac{(\sum_I Y_{ij}.I_j)^2}{\sum_j I^2 j}$ = The variance due to regression.

Because,

$$\frac{(\sum_j Y_{ij}.I_j)^2}{\sum_j I^2} = \frac{(\sum_j Y_{ij}.I_j)\ (\sum_i Y_{ij}.I_j)}{\sum_j I^2} = bi \sum_j Y_{ij}.I_j$$

Where,

bi values are calculated in IInd (iii) and $\sum_j Y_{ij}.I_j$ values in IInd (ii).

The $\sum_j d^2 ij$ values may be computed as,

$$\sum_j d^2 ij = \sum_j d^2\ ij - bi \sum_j Y_{ij}.I_j$$

From $\sum_j d^2 ij$, the stability parameter S^2di for each variety was computed as follows.

$$S^2di = \left[\frac{\sum_j d^2 ij}{(S-2)} - \frac{S^2e}{r} \right]$$

3.5.1.5 Analysis of variance

The analysis of variance was partitioned into three parts.

i. Sum of squares due to genotypes.

ii. Sum of squares due to environment + genotype x environment and

iii. Pooled error.

The sum of squares due to genotype x environment was further partitioned into two parts i.e.

a. S.S. due to genotype x environment (linear) which is in fact S.S. due to regression.

b. S.S. due to deviation from linearity of response (i.e. S.S. due to pooled deviation).

The latter was further partitioned in to as many components as the number of genotypes with (S-2) degree of freedom (S : represents number of seasons/environments).

The analysis of variance table for stability parameters (Eberhart and Russell, 1966) was constructed as below :

Source	D.F.	M.S.
Genotypes	(t-1)	MS_1
Environments	(S-1)	MS_2
Genotypes x Environments	(t-1) (S-1)	MS_3
Environments + (Genotype x Environment)	t (S-1)	
Environment (linear)	1	MS_4
Genotype x Environment (Linear)	(t-1)	MS_5
Pooled deviation	t (S-2)	MS_6
Pooled error	S (r-1) (t-1)	MS_7

Where,

t = Number of varieties

s = Number of environments

r = Number of replications

S.S. due to variety, environments and variety x environments were calculated as per the method of pooled analysis.

The M.S. pooled error was calculated as :

$$= \frac{(n_1-1)\ (\text{M.S. error } L_1) + \ldots + (n_s-1)\ (\text{MS error } L_s)}{(n_1-1) + (n_2-1)\ \ldots\ (n_s-1)}$$

Where,

M.S. error L_s = Mean of sum of squares due to error for sth environment

(n_1-1) = Error d.f. in environment - 1

(n_2-1) = Error d.f. in environment - 2

The sum of squares due to the remaining sources were calculated as follows :

S.S. due to environment (seasons) + (genotype x environment)

$$= \sum_i \sum_j Y^2_{ij} - \sum_i \frac{Y^2_{i.}}{t}$$

In fact, SS (E x G x E) = S.S.E. + S.S.G. x E

Where,

$$S.S.E. = (1/t)\ (\sum_j Y_{.j}.I_j / \sum_j I^2_j)$$

The Y.j and I_j values are already computed and by putting appropriate values, the S.S. environment (linear) was estimated which can also be checked as :

$$S.S.\ environment\ (linear) = t \times \sum_j I^2_j$$

$$S.S.\ G \times E\ (linear) = \left(\frac{(\sum_j Y_{ij}\ I_j)^2}{\sum_j I^2_j}\right) - S.S.\ environment\ (linear)$$

Where,

$$\frac{(\sum_j Y_{ij}\ I_j)^2}{\sum_j I^2_j} = b_i \sum_j Y_{ij}.I_j \text{ for each variety}$$

Thus, by taking simply the sum of these values over all the genotypes the first part of S.S. G x E (Linear) was obtained. S.S. due to pooled deviation is simply the sum of S.S. due to deviation for individual variety for (S-2) degree of freedom each.

3.5.1.6 Test of significance

a. In order to test the significance of the differences among varieties (MS_1), environment (MS_2), the respective mean squares were tested against M.S. genotype x environment (MS_3). The genotypic differences were also tested against pooled deviation (MS_6).

b. The genotype x environment (MS_3) interaction was tested against effective pooled error.

c. The components, environment (linear), genotype x environment (Linear) were tested against pooled deviation (MS_6).

d. Pooled deviations were tested against effective pooled error (PE/r) and the indiviaual deviation from linear regression was tested as follows :

$$F = \frac{\sum_j \delta_{ij}^2 / (S-2)}{\text{Pooled error}}$$

3.5.2 Stable genotype

A genotype with unit regression coefficient (b_i=1) or non-significantly deviating from unity and the deviation not significantly different from zero ($S^2 d_i \approx 0$) is said to be stable one :

$$S.E.\ (b_i) = \sqrt{\frac{M.S.\ \text{due to pooled deviation}}{\sum_j I^2_j}}$$

The significance of b_i values was tested by 't' test as (against unity) as below :

$$t_{cal} = \frac{b_i - 1}{SE\ (b_i)}$$

3.5.3 Correlation coefficients

a. Estimation of components of variances :

The phenotypic and genotypic variances were calculated by using the respective mean square values from the variance table (Johnson et al., 1955).

Environmental variance $6^2{}_e$ = EMS/γ

Genotypic variance $6^2{}_g = \frac{GMS - EMS}{r}$

Phenotypic variance $6^2{}_p = 6^2 g + 6^2 e$

b. Estimation of covariances :

Analysis of covariance between all the pairs of the characters under study was carried out as per the procedure of analysis of variance and covariance as described by Singh and Chaudhari (1979) as under.

Environmental covariance ($e^{cov}1.2$) = EMS/γ

Genotypic covariance ($g^{cov}1.2$) $= \frac{GMS - EMS}{r}$

Phenotypic covariance ($p^{cov}1.2$) $= e^{cov}1.2 + g^{cov}1.2$

The appropriate variances and covariances were used to calculate phenotypic and genotypic correlation coefficients (Johnson *et al.*, 1955) as below :

The phenotypic correlation coefficient.

$$(rp) = \frac{p^{cov}\ 1.2}{\sqrt{(6^2 P_1)\ (6^2 P_2)}}$$

derive $rP_{1.2}$

Where,

$P^r{}_{1.2}$	=	Phenotypic correlation between character 1 and 2
$P^{cov}{}_{12}$	=	Phenotypic covariance between character 1 and 2
$(6^2 P_1)\ (6^2 P_2)$	=	Phenotypic variances of character 1 and 2, respectively.

The genotypic corelation coefficient (rg) were obtained by the formula.

$$g^{\ 1.2} = \frac{g^{cov}{}_{1.2}}{\sqrt{(6^2 g_1)\ (6^2 g_2)}}$$

Where,

$g^r{}_{1.2}$	=	Genotypic correlation between characters 1 and 2, respectively
$g^{cov}{}_{1.2}$	=	Genotypic covariance between character 1 and 2, respectively
$(6^2 g_1)\ (6^2 g_2)$	=	Genotypic variance of characters 1 and 2, respectively.

The significance of phenotypic ( ) correlation coefficients was tested by the method of Fisher and Yates (1943).

This can not be tested

$$t_{cal} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

Where,

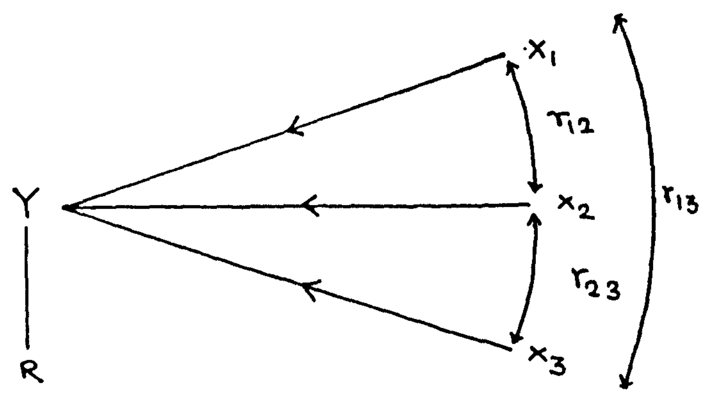
r = Correlation coefficient

n = Total number of observations

The calculated `t' value was tested with table `t' value for respective (n-2) degree of freedom for significance.

3.5.4 Path analysis

Path coefficient analysis as suggested by De Wey and Lu (1959) was used to partition the correlation coefficients into direct and indirect effects. The first step in path analysis is to prepare the path diagram based on cause and effect relationship. In the present study, path diagram was prepared by taking yield as effect i.e. the function of various compoents like X_1, X_2, X_3 and these components show following type of association with each other.



In path diagram the yield was considered as the result of X_1, X_2, X_3 and some other undefined factors designated by R. The double arrowed lines indicated mutual association as measured by correlation coefficient and the single arrowed line represent direct influence as measured by path coefficient (P_{ij}).

Path coefficients were obtained by solving a set of simultaneous equations of the form as per De w y and Lu (1959).

$$r_{ny} = P_{ny} + rn_2 \cdot P_2Y + rn_3 \cdot P_3Y + \ldots.$$

Where,

r_{ny} = represents the correlation between one component and yield, P_{ny} = represent path coefficients between that character and yield and rn_2 = represents correlation between that character and each of other components in turn.

Matrix A Matrix B

$$\begin{bmatrix} r_{1y} \\ r_{2y} \\ r_{ny} \end{bmatrix} \qquad \begin{bmatrix} r_{11} & r_{12} & r_{13} & \cdots\cdots & r_{1n} \\ r_{21} & r_{22} & r_{23} & \cdots\cdots & r_{2n} \\ r_{n1} & r_{n2} & r_{n3} & \cdots\cdots & 1 \end{bmatrix}$$

Where,

$r_{12} = r_{21}$ and so on and r_{1y} correlation between one component character and yield. The B matrix was inverted (B^{-1}), and path coefficients (P_{ij}) were obtained as

$$P_{ij} = A \times B^{-1}$$

The indirect effects of a particular character through other characters were obtained by multiplication of direct paths and particular correlation coefficients between these characters separately.

$$\text{Indirect effect} = r_{ij} \times P_{ij}$$

Where,

i = 1 to 11

j = 1 to 11

P_{ij} = P_{1y}, P_{2y} .... P_{ny}

Path coefficients (P_{ij}) correlation coefficients (r_{ij}) and residual factor (R) were diagramatically presented. The residual factor, i.e. variation in yield unaccounted for by these associations was calculated from following formula.

$$\text{Residual factor (R)} = \sqrt{1 - R^2}$$

Where,

$$R^2 = P_{1y}.r_{1y} + P_{2y}.r_{2y} + ... + P_{ny}.r_{ny}$$

Where,

P_{1y}, P_{2y} ...... P_{ny} = Path values

r_{1y}, r_{2y} ...... r_{ny} = Correlation coefficients

Experimental Results

4. EXPERIMENTAL RESULTS

The results of the present investigation are narrated below under different heads.

4.1 Stability

4.1.1 Analysis of Variance

In order to know the significance of differences due to various genotypes evaluated, the analysis of variance for each charactor in each environment and in each cut was constructed. The genotypic mean sum of squares are presented in Table 2. The differences due to genotypes for each cut in each pre-detectable environment for all the characters studied except number of tillers per plant for third cut in E_3 environment, were significant.

4.1.2 Analysis of Variance (after Eberhart and Russell, 1966)

The analysis of variance representing the mean squares due to different sources of variation after Eberhart and Russell's (1966) stability analysis, is presented in Table 3, 4 and 5 for three cuts in E_1 (Sowing in first week of December with 20 Kg N + 80 Kg P_2O_5/ha as a basal dose (F_1), E_2 (Sowing in first week of December with 30 Kg N + 120 Kg P_2O_5/ha as basal dose (F_2), E_3 (Sowing in last week of December with 20 Kg N + 80 Kg P_2O_5 as a basal dose plus 10 Kg N + 40 Kg P_2O_5/ha after the first cut (F_3) environments, respectively and in Table 6 for nine environments (Pooled).

Talbe 2 : Genotypic mean sum of squares for different pre-dictable environment

Sr. No.	Character	E_1			E_2			E_3		
		Ist cut	IInd cut	IIIrd cut	Ist cut	IInd cut	IIIrd cut	Ist cut	IInd cut	IIIrd cut
1.	Plant height	111.59**	199.06**	217.41**	266.91**	655.85**	33.28**	245.31**	114.81**	77.89**
2.	Number of tillers/ plant	0.46**	0.56**	0.63**	0.50**	0.93**	0.61**	0.30**	0.59**	0.17
3.	Number of tillers/ meter length	106.82**	220.50**	173.68**	106.23**	466.62**	251.63**	88.54**	550.43**	97.44**
4.	L/S ratio	0.02**	0.02**	0.01**	0.014**	0.014**	0.006**	0.007**	0.007**	0.009**
5.	Green fodder yield/ plant (GFY)	34.91**	41.09**	23.51**	66.06**	83.62**	15.37**	29.13**	31.33**	16.71**
6.	Dry fodder yield/ plant (DFY)	0.39**	1.16**	0.39**	1.19**	2.19**	1.70**	0.34**	1.17**	0.87**
7.	Crude protein content	0.03**	0.10**	0.04**	0.051**	0.11**	0.11**	0.03**	0.07**	0.06**
8.	Green fodder yield/ meter distance (GFY)	8513.61**	13949.37**	14710.79**	23078.48**	13050.00**	14695.11**	5907.42**	21993.21**	7881.47**

** Significant at P = 0.01.

Table 3 : ANOVA for stability with three cuts in first environment (E_I)

Sr. No.	Character	Mean sum of squares							
		Genotype	Environment	G x E	Env+(GxE)	Env (Linear)	GxE (Linear)	Pooled deviation	Pooled error
	D.F.	19	2	38	40	1	19	20	114
1.	Plant height	120.69++**	5708.03++	27.67@@	311.68	11416.05**	40.27*	14.30@@	3.219
2.	Number of tillers/ plant	0.4005++**	17.78++	0.07338@@	0.9585	35.55**	0.09287*	0.05119	0.037
3.	Number of tillers/ meter length	104.11++**	20100.51++	31.44@@	1034.89	40201.02**	32.77	28.62@@	1.702
4.	L/S ratio	0.009887+	0.004314	0.004375@@	0.004372	0.008628	0.003360	0.005121@@	0.0005
5.	Green fodder yield/ plant (GFY)	25.23++**	733.08++	3.9737@@	40.43	1466.16**	6.06**	1.79@@	0.125
6.	Dry fodder yield/ plant (DFY)	0.5012++**	64.06++	0.07325@@	3.2727	128.13**	0.6578**	0.07667@@	0.083
7.	Crude protein content	0.04226++**	1.9020++	0.008372@@	0.1031	3.8040**	0.007064	0.009195@@	0.002
8.	Green fodder yield/ meter distance (GFY)	9528.58++**	44308.00++	1431.34@@	3575.18	88614.81**	1825.29*	985.51@@	56.17

+ and ++ Significant at P=0.05 and 0.01, respectively when tested against G x E

* and ** Significant at P=0.05 and 0.01, respectively when tested against pooled deviation

@ and @@ Significant at P=0.05 and 0.01, respectively when tested against effective pooled error.

Table 4 : ANOVA for stability with three cuts in second environment (E_2)

Sr. No.	Character	Mean sum of squares							
		Genotype	Environment	G x E	Env+(GxE)	Env (Linear)	GxE (Linear)	Pooled deviation	Pooled error
	D.F.	19	2	38	40	1	19	20	114
1.	Plant height	201.20++**	3407.61++	58.74@@	226.18	6815.20**	87.51**	28.47@@	1.998
2.	Number of tillers/ plant	0.4363++**	21.20++	0.1237@@	1.1775	42.3988**	0.1545	0.08828@@	0.020
3.	Number of tillers/ meter length	151.25++**	16336.41++	61.7878@@	875.52	32672.83**	82.2116*	39.30@@	1.754
4.	L/S ratio	0.006276++**	0.002237	0.002643@@	0.002623	0.004473	0.002909	0.002259@@	0.00025
5.	Green fodder yield/ plant (GFY)	46.22++**	957.58++	4.3996@@	52.06	1915.16**	6.6752**	2.0175@@	0.148
6.	Dry fodder yield/ plant (DFY)	1.37++**	44.48++	0.1603@@	2.38	88.95**	0.23*	0.08969@@	0.0028
7.	Crude protein content	0.07654++**	1.5646++	0.006691@@	0.08459	3.1294**	0.005373	0.007609@@	0.00009
8.	Green fodder yield/ meter distance (GFY)	15422.21++**	22930.50++	759.50@@	1868.05	45861.85**	302.3061	1155.86@@	36.412

+ and ++ Significant at P=0.05 and 0.01, respectively when tested against G x E

* and ** Significant at P=0.05 and 0.01, respectively when tested against pooled deviation

@ and @@ Significant at P=0.05 and 0.01, respectively when tested against effective pooled error.

Table 5 : ANOVA for stability with three cuts in third environment (E_3)

Sr. No.	Character	Mean sum of squares							
		Genotype	Environment	G x E	Env+(GxE)	Env (Linear)	GxE (Linear)	Pooled deviation	Pooled error
	D.F.	19	2	38	40	1	19	20	114
1.	Plant height	101.51++**	1013.40++	22.25@@	71.81	2026.79**	14.94	28.09@@	1.29
2.	Number of tillers/ plant	0.2102++**	23.92++	0.07176@@	1.2643	47.85**	0.07448	0.06559@@	0.0257
3.	Number of tillers/ meter length	129.55+**	30957.36++	57.96@@	1602.93	61914.71**	99.93**	15.19@@	1.462
4.	L/S ratio	0.005105++**	0.05028++	0.001462@@	0.003903	0.1006**	0.001577	0.001280@@	0.00024
5.	Green fodder yield/ plant (GFY)	21.27++**	1166.32++	2.23@@	60.43	2332.64**	2.8237	1.55@@	0.14
6.	Dry fodder yield/ plant (DFY)	0.6770++**	64.50++	0.05730@@	3.28	128.99**	0.07926*	0.03355@@	0.0028
7.	Crude protein content	0.04910++**	1.7858++	0.003506@@	0.09262	3.572**	0.004103	0.002763@@	0.00008
8.	Green fodder yield/ meter distance (GFY)	9072.63++**	180771.50++	1428.16@@	10395.33	361543.00**	1949.90*	861.10@@	36.991

+ and ++ Significant at P=0.05 and 0.01, respectively when tested against G x E

* and ** Significant at P=0.05 and 0.01, respectively when tested against pooled deviation

@ and @@ Significant at P=0.05 and 0.01, respectively when tested against effective pooled error.

Pooled analysis of variance for each environment over three cuts (Table 3 to 5) showed that genotypic variances when tested against G x E and pooled deviation were significant for all the characters except leaf/stem ratio when tested against pooled deviation in first environment. Environmental variances were significant for all the characters except L/S ratio in first (E_1) and second (E_2) environments.

The data in Table 3 to 5, further indicated the significance of G x E interaction for all the characters studied. Partitioning of G x E interaction showed that G x E (linear) effects were significant for plant height, number of tillers per plant, green forage yield per plant, dry fodder yield per plant and green fodder yield per meter in first (E_1) environment while, for plant height, number of tillers per meter, green fodder yield per plant and dry fodder yield per plant in second (E_2) environment, while in third (E_3) environment only for number of tillers per meter length, dry fodder yield per plant and green fodder yield per meter. However, pooled deviation (non-linear) effects were significant for all the characters in all the environments except number of tillers per plant in first environment when tested against effective pooled error. Environment (linear) effects were significant for all the characters in all the environments except L/S ratio in first and second environment.

Pooled analysis of variance over nine environments (Table 6), showed significant genotypic differences for all the characters when tested against both G x E and pooled deviation. Similarly, environmental variances were also significant for all the characters. The data in Table 6, further indicated the significance of G x E interaction for all the characters studied. Partitioning of G x E interaction showed that G x E (linear) effects were significant for plant height, number of tillers per meter length, green fodder yield per plant, dry fodder yield per plant and green fodder yield per meter distance. Pooled deviation effects, however, were significant for all the characters when tested against effective pooled error. Environment (linear) effects were also significant for all the characters.

4.1.3 Environmental indices

Estimates of environmental indices (I_j) presented in Table 7, revealed that the first cut was favourable for all the characters in first environment, while it was favourable for almost all the characters except green fodder yield per plant and plant height in second and third environments, respectively. The second cut in second environment was favourable for L/S ratio only. However, the third cut was favourable for plant height, number of tillers per meter distance, green fodder yield per plant and per meter distance, in all environments. It was also favourable for L/S ratio in third environment.

Table 6 : ANOVA for stability with nine environments (Eberhart and Russell, 1966) for pooled analysis

Sr. No.	Character	Mean sum of squares							
		Genotype	Environment	G x E	Env+(GxE)	Env (Linear)	GxE (Linear)	Pooled deviation	Pooled error
	D.F.	19	8	152	160	1	19	140	342
1.	Plant height	374.02++**	2561.61++	33.34@@	159.75	20492.88**	55.66**	28.64@@	2.169
2.	Number of tillers/ plant	0.8721++**	16.12++	0.08909@@	0.8907	128.97**	0.1086	0.08199@@	0.027
3.	Number of tillers/ meter length	308.41++**	17325.68++	47.36@@	911.28	138605.50**	121.52**	34.93@@	1.639
4.	*L/S ratio*	0.009371++*	0.01655++	0.003607@@	0.004254	0.1324**	0.002187	0.003620@@	0.0003
5.	Green fodder yield/ plant (GFY)	85.52++**	860.61++	3.550@@	46.40	6884.88**	9.960**	2.502@@	0.137
6.	Dry fodder yield/ *plant (DFY)*	2.301++**	45.29++	0.1041@@	2.363	362.30**	0.2572**	0.07809@@	0.0028
7.	Crude protein content	0.1543++**	1.3798++	0.006343@@	0.07502	11.04**	0.008590	0.005722@@	0.0007
8.	Green fodder yield/ meter distance (GFY)	31587.58++**	83081.00++	1209.32@@	5302.90	664645.50**	2541.60**	967.98@@	43.192

+ and ++ Significant at P=0.05 and 0.01, respectively when tested against G x E

* and ** Significant at P=0.05 and 0.01, respectively when tested against pooled deviation

@ and @@ Significant at P=0.05 and 0.01, respectively when tested against effective pooled error.

Table 7 : Estimation of environmental index (I_j) under different seasons (environments)

Sr. No.	Character	E_1			E_2			E_3		
		Ist cut	IInd cut	IIIrd cut	Ist cut	IInd cut	IIIrd cut	Ist cut	IInd cut	IIIrd cut
1.	Plant height	6.4261	-18.9207	12.4946	2.8988	-14.1982	11.2994	-2.3625	-5.6315	7.9940
2.	Number of tillers/ plant	1.0719	-0.7346	-0.3373	1.1803	-0.4432	-0.7371	1.2620	-0.6455	-0.6165
3.	Number of tillers/ meter length	10.6801	-36.1687	25.4886	18.2327	-32.9494	14.7167	18.1396	-45.1622	27.0226
4.	L/S ratio	0.0158	-0.0067	-0.0091	0.0078	0.0033	-0.0111	0.0196	-0.0678	0.0482
5.	Green fodder yield/ plant (GFY)	0.7213	-6.3856	5.6643	-8.8259	-6.4694	7.2933	1.5867	-8.2673	6.6806
6.	Dry fodder yield/ plant (DFY)	1.9659	-1.4408	-0.5251	1.6753	-1.1822	-0.4931	1.8995	-1.6715	-0.2280
7.	Crude protein content	0.3530	-0.2300	-0.1230	0.3190	-0.2015	-0.1175	0.3217	-0.2678	-0.0539
8.	Green fodder yield/ meter distance (GFY)	44.9998	-48.5827	3.5829	22.4715	-38.9440	16.4725	92.4390	-97.4790	5.0400

4.1.4 Stability parameters

Since G x E interaction was detected for all the characters studied, the stability parameter in respect of all the characters were estimated over three cuts in each environment and also for nine environments (3 cuts each 3 environments) and presented in Table 8 to 15. The non-significant values for b_i were considered as around unity irrespective of their high or low numerical values.

4.1.2.1 **Plant height**

The stability parameters for three and nine environments are presented in Table 8. Ten genotypes in second (E_2) and nine environments had higher pooled average means than the population mean for this trait. In first (E_1) and third (E_3) environment eleven genotypes had higher mean than the population mean. Five, twelve, thirteen and ninteen genotypes in first (E_1), second (E_2), third (E_3) and nine environments, respectively had significant S^2di values indicating their instability for this character.

The genotype, JHB-93-3 recorded high mean plant height with bi around unity and non-significant S^2di value indicating its stability for this trait over all the environments and also over three cuts in each environment. Besides this, the genotypes viz., BL-122, BL-131 in first (E_1) environment, the genotypes JB-92-1, JHB-92-2, JHB-146, HFB-135 and Mescavi in E_1 and E_2. RHB-93-4 in E_2, JHB-93-2 and Wardan in E_3 and the genotype, JHB-93-4 both in E_2 and E_3

Table 8: Stability parameters (Eberhart and Russell, 1966) for plant height (cm)

Sr. No.	Genotype	E_1			E_2			E_3			Nine Environments		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BL-102	47.38	1.13	52.84**	52.23	0.72	61.59**	50.29	0.97	4.24	49.97	0.96	29.27**
2.	BL-122	54.51	1.27	2.090	50.02	0.65	3.58	48.92	0.98	3.39	51.15	1.04	15.20**
3.	BL-126	51.67	0.73	-2.50	51.44	0.81	21.32	57.31	1.57	13.79**	51.47	0.83	13.17**
4.	BL-130	48.64	0.72	-3.19	47.73	0.76	16.24**	49.30	1.49	31.10**	48.56	0.80	15.10**
5.	BL-131	56.25	1.12	-1.43	55.15	1.83*	43.56**	51.80	1.56	15.15**	54.40	1.40*	22.95**
6.	JB-90-2-56	55.75	1.47**	45.3**	58.60	1.44	45.76**	52.63	1.20	75.83**	56.66	1.43*	26.82**
7.	JB-92-1	58.55	1.22	-1.67	52.89	1.34	-0.89	51.35	1.01	54.78**	54.27	1.25	13.27**
8.	JHB-92-2	55.57	0.78*	1.76	59.00	1.39	3.57	54.12	1.20	11.23**	56.23	1.29	16.30**
9.	JHB-93-2	48.91	0.47**	9.41	51.03	0.71	75.30**	51.27	0.91	-1.25	50.40	0.58*	17.48**
10.	JHB-93-3	58.07	1.09	-3.11	56.75	1.30	2.66	54.20	1.58	0.52	56.34	1.21	2.55
11.	JHB-93-4	62.49	0.70	17.72	65.73	1.49	-1.26	63.27	0.75	3.41	63.83	0.96	25.10**
12.	JHB-146	53.91	0.97	-2.58	59.43	1.26	6.27	50.15	1.37	60.10**	54.50	1.12	24.04**
13.	HFB-135	60.78	1.14	19.44	62.73	1.44	-1.30	55.55	0.88	9.50**	59.69	1.23	10.97**
14.	RMBS-93-0-1	38.84	1.16	9.41	42.38	0.39*	11.42**	40.89	0.69	60.20**	40.70	0.84	34.08**
15.	RMBS-93-0-2	40.68	0.88	5.47	41.42	0.37*	52.73**	39.75	0.51	61.94**	40.62	0.67	24.65**
16.	RMBS-93-0-3	48.42	0.94	1.69	37.58	0.27*	21.78**	44.82	0.67	-1.11	43.61	0.68	42.21**
17.	RMBS-93-3	49.31	1.33*	4.09	40.49	0.28*	85.01*	44.60	0.57	26.52**	44.80	0.90	66.52**
18.	RMBS-93-5-2	51.71	1.33	35.87**	42.49	0.42	16.09**	41.22	0.21	83.14**	45.14	0.93	70.90**
19.	Wardan	60.24	0.75	40.78**	60.78	1.61*	67.47**	57.54	0.98	0.14	59.52	1.06	37.25**
20.	Mescavi	57.41	0.80	-2.71	59.49	1.51	-1.53	52.89	0.89	23.30**	56.58	1.06	31.54**
	Mean	52.95			52.37			50.29			51.87		
	S.E.±	2.67	0.16		3.77	0.29		3.75	0.53		1.89	0.17	

Where, $\bar{X}$ = Mean, bi = Regression coefficient, S^2di = Mean square deviation
*, ** = Significant at P=0.05 and P=0.01, respectively.

also had high mean plant height with bi around unity and non-significant S^2di values indicating their stability over three cuts in respective environments.

4.1.2.2 **Number of tillers per plant**

The stability parameters for this trait presented in Table 9, revealed wider adaptibility of the genotypes viz., JHB-92-2, JHB-93-4, HFB-135, Wardan and Mescavi as they had non-significant S^2di values, 'bi' values at unity and higher mean performance in a set of both three and nine environments. Besides, the genotypes, RMBS-93-0-3 and RMBS-93-3 in first (E_1) environment, BL-122 and JB-92-1 in second (E_2) environment and BL-131 in third (E_3) environment, also had more number of tillers per plant, non-significant S^2di values and bi values around unity indicating their stability for this trait in a set of respective environments.

In second environment the genotype BL-126 had high mean, with bi > 1 and non-significant S^2di indicating its stability to rich environment i.e. below average stability.

4.1.2.3 **Number of tillers per meter distance**

The stability parameters presented in Table 10, showed that all the genotypes except BL-122 in first (E_1) environment and except JB-92-1 over nine environments were unstable as they exhibited significant S^2di in respective set of environments. The genotype, BL-126 in third (E_3) environment had 'bi' significantly greater than unity, high mean performance and non-significant S^2di indicating its adaptability for rich environment for this trait.

Table 9: Stability parameters (Eberhart and Russell, 1966) for number of tillers per plant

Sr. No.	Genotype	E_1			E_2			E_3			Nine Environments		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BL-102	4.80	0.96	-0.006	4.61	0.64	0.183	5.20	0.90	0.022	4.87	0.83	0.090**
2.	BL-122	4.89	1.08	-0.037	5.22	1.03	-0.013	5.07	0.84	0.016	5.06	0.97	0.002
3.	BL-126	4.58	0.97	0.093	5.15	1.47*	0.012	5.11	0.93	-0.025	4.95	1.15	0.072*
4.	BL-130	4.62	0.52*	-0.037	5.11	1.07	0.001	5.20	0.74	-0.014	4.98	1.82	0.049
5.	BL-131	4.68	0.87	0.043	5.02	1.29	0.038	5.35	0.75	-0.001	5.02	0.99	0.075**
6.	JB-90-2-56	4.51	1.05	0.072	4.88	1.26	-0.019	5.14	1.01	-0.007	4.84	1.13	0.020
7.	JB-92-1	4.78	0.96	0.065	5.27	1.09	-0.011	5.15	0.86	0.095	5.07	0.98	0.031
8.	JHB-92-2	5.05	0.91	0.058	5.59	0.89	-0.014	5.50	0.87	-0.023	5.38	0.91	0.011
9.	JHB-93-2	4.80	0.84	0.006	5.09	1.10	0.210**	5.32	1.10	-0.023	5.07	1.04	0.033
10.	JHB-93-3	4.72	1.10	0.057	5.00	0.99	0.077	5.31	0.77	0.105*	5.01	0.96	0.054
11.	JHB-93-4	5.92	1.28	-0.021	6.15	1.09	-0.018	6.04	1.09	0.042	6.04	1.13	0.006
12.	JHB-146	4.75	1.43*	-0.0005	5.11	1.43	0.050	5.35	0.86	-0.020	5.07	1.23	0.066*
13.	HFB-135	5.45	1.03	-0.013	5.68	1.06	0.024	5.47	1.32	0.018	5.53	1.13	0.036
14.	RMBS-93-0-1	4.78	0.68	0.039	5.13	0.82	0.067	5.09	1.13	-0.021	5.00	0.90	0.034
15.	RMBS-93-0-2	4.95	0.98	-0.022	4.84	0.79	0.005	5.18	1.14	-0.025	4.99	0.96	0.023
16.	RMBS-93-0-3	5.03	0.87	-0.006	4.82	0.68	0.088*	5.09	1.12	-0.012	4.98	0.88	0.063*
17.	RMBS-93-3	5.07	0.83	-0.024	4.82	0.55	0.595**	4.84	0.93	0.647**	4.91	0.73	0.237**
18.	RMBS-93-5-2	4.93	1.52**	0.033	4.95	0.50	0.081*	5.02	1.29	0.018	4.97	1.07	0.183**
19.	Wardan	5.63	1.02	-0.033	5.77	1.09	-0.006	5.68	1.12	0.010	5.69	1.06	0.0006
20.	Mescavi	5.31	1.07	0.020	5.54	1.12	0.010	5.45	1.21	-0.006	5.44	1.13	0.002
	Mean	4.96			5.19			5.28			5.14		
	S.E.±	0.16	0.17		0.21	0.20		0.18	0.16		0.10	0.11	

Where, $\bar{X}$ = Mean, bi = Regression coefficient, S^2di = Mean square deviation

*, ** = Significant at P=0.05 and P=0.01, respectively.

Table 10 : Stability parameters (Eberhart and Russell, 1966) for number of tillers per metre distance

Sr. No.	Genotype	E_1			E_2			E_3			Nine Environments		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BL-102	60.89	0.99	16.38**	70.00	0.90	108.90**	64.22	0.97	39.56**	65.04	0.96	24.41**
2.	BL-122	63.61	1.00	5.10	67.67	1.20	50.78**	65.89	1.02	1.46	65.74	1.04	27.55**
3.	BL-126	61.89	0.96	10.67*	77.55	1.02	1.72	74.89	1.34**	3.50	71.44	1.15*	49.82**
4.	BL-130	54.55	1.04	73.25**	68.22	0.82	156.84**	57.11	0.95	76.55**	59.96	0.95	52.56**
5.	BL-131	63.89	1.03	21.35**	86.89	1.64**	6.66	82.89	1.34**	59.27**	77.89	1.33**	108.37**
6.	JB-90-2-56	61.55	0.91	43.50**	69.44	1.07	27.08**	62.00	0.86	6.47**	64.33	0.92	18.35**
7.	JB-92-1	59.22	1.07	8.20*	67.67	1.06	4.81	61.22	1.03	0.94	62.70	1.04	3.26
8.	JHB-92-2	67.89	1.05	24.53**	79.00	1.02	1.59	69.67	1.00	1.13	72.18	1.02	3.61*
9.	JHB-93-2	62.67	1.07	11.19*	76.00	1.00	5.65	58.89	0.55**	9.86*	65.85	0.83*	84.04**
10.	JHB-93-3	62.22	1.02	24.04**	73.44	1.04	10.76**	65.44	0.95	10.10**	60.04	1.00	7.18
11.	JHB-93-4	78.22	0.97	9.07*	89.22	1.03	14.58**	76.89	1.00	1.08	81.44	1.00	8.34
12.	JHB-146	56.11	0.76	20.28**	70.11	0.73	8.10*	63.55	0.79**	0.56	63.37	0.78**	12.53**
13.	HFB-135	71.00	1.03	33.31**	82.22	1.08	15.48**	69.89	0.97	0.41	74.37	1.02	13.42**
14.	RMBS-93-0-1	62.67	0.81	19.98**	74.78	0.88	0.48	64.00	1.03	22.36**	67.15	0.93	16.69**
15.	RMBS-93-0-2	64.89	1.18	20.43**	64.11	1.03	327.87**	67.00	1.14	8.54*	65.33	1.09	96.12**
16.	RMBS-93-0-3	62.33	1.22	80.21**	69.67	0.57*	1.80	71.00	1.07	2.46	67.67	0.98	89.62**
17.	RMBS-93-3	57.78	0.71*	60.07*	70.22	0.61*	0.62	58.44	0.79**	20.93**	62.15	0.74**	23.93**
18.	RMBS-93-5-2	62.89	1.13	8.77*	75.33	1.09	0.56	64.22	1.19	19.28**	67.48	1.15*	6.01**
19.	Wardan	74.33	0.99	36.06**	85.44	1.08	10.06*	73.00	1.04	1.05	77.59	1.04	12.19**
20.	Mescavi	70.44	1.05	11.86**	80.22	1.10	0.12	69.33	0.96	1.45	77.33	1.02	7.77**
	Mean	63.95			74.88			66.98			68.60		
	S.E.±	3.78	0.12		4.43	0.15		2.75	0.07		2.09	0.07	

Where, $\bar{X}$ = Mean, bi = Regression coefficient, S^2di = Mean square deviation
*, ** = Significant at P=0.05 and P=0.01, respectively.

The genotypes viz., BL-126, BL-131, JHB-92-2, JHB-93-2, RMBS-93-5-2 and Mescavi in second (E_2) and JHB-92-2, JHB-93-4, HFB-135, RMBS-93-0-3, Wardan and Mescavi in third (E_3) environment had bi not significantly deviating from unity, mean higher than population mean and non-significant S^2di indicating their wider adaptability over three cuts in E_2 and E_3 for number of tillers per meter distance.

4.1.3.4 **Leaf/stem ratio**

A persual of Table 11, revealed that all the genotypes over all the environments had significant S^2di values indicating their instability for this trait over environments. However, the genotypes, viz., JHB-93-2, JHB-93-4, JHB-146, RMBS-93-0-1, RMBS-93-0-2, RMBS-93-5 and Mescavi in first (E_1) environment BL-122, BL-126, JB-92-1 and JHB-146 in second (E_2) environment and RMBS-93-0-3, RMBS-93-3 and Mescavi in third (E_3) environment exhibited wider adaptability over respective environments as they had `b' vlaues not significantly deviating from unity, non-significant S^2di values and higher mean performance than population mean. Though the genotype Mescavi exhibited wider adaptability in E_1 and E_3 environments, it had bi significantly greater than unity, high mean performance and non-significant S^2di in E_2 environment indicating its suitability for rich environment for this trait. The genotype, BL-102 in third (E_3) environment had `bi' significantly less than unity. Mean higher than population

Table 11: Stability parameters (Eberhart and Russell, 1966) for leaf/stem ratio

Sr. No.	Genotype	E_1			E_2			E_3			Nine Environments		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BL-102	0.68	-2.25	0.001	0.81	-2.21	0.005**	0.79	-0.11*	-0.0002	0.76	0.42	0.005**
2.	BL-122	0.80	-2.77	0.001**	0.82	-0.01	0.001	0.70	0.42	0.0001	0.78	0.26	0.005**
3.	BL-126	0.72	-1.43	0.010**	0.81	2.34	0.0003	0.73	1.21	0.004**	0.75	1.42	0.003**
4.	BL-130	0.69	2.57	0.003*	0.76	0.71	0.001**	0.69	1.82	-0.0002	0.71	1.92	0.001**
5.	BL-131	0.68	7.10	0.017**	0.72	2.44	0.001**	0.81	0.68	0.001*	0.74	1.33	0.001**
6.	JB-90-2-56	0.63	5.46	0.0005	0.74	3.57	-0.0002	0.70	0.54	0.001	0.69	1.50	0.002**
7.	JB-92-1	0.72	1.39	0.007**	0.81	3.45	-0.0003	0.77	1.30	0.001*	0.77	1.74	0.002**
8.	JHB-92-2	0.76	-0.26	0.002*	0.80	-0.89	0.001*	0.78	1.43	0.002**	0.78	1.27	0.001**
9.	JHB-93-2	0.75	0.80	0.001	0.82	2.36	0.002**	0.75	1.82	-0.0001	0.77	1.90	0.001**
10.	JHB-93-3	0.71	-2.74	0.001	0.74	-4.51	0.004**	0.76	1.33	0.002**	0.74	0.83	0.003**
11.	JHB-93-4	0.78	1.80	-0.0001	0.77	-0.65	0.001	0.80	0.97	0.001*	0.78	0.79	0.001**
12.	JHB-146	0.81	-0.77	-0.0001	0.82	4.12	-0.0002	0.75	0.88	0.001	0.79	0.85	0.002**
13.	HFB-135	0.64	0.79	0.002*	0.67	6.29	0.002**	0.75	1.03	0.001	0.69	1.20	0.004**
14.	RMBS-93-0-1	0.76	-1.29	-0.0002	0.73	3.52	-0.0002	0.73	1.87	0.003**	0.74	1.29	0.002**
15.	RMBS-93-0-2	0.81	2.90	-0.0003	0.72	2.50	0.001**	0.70	1.09	-0.0002	0.75	-0.19	0.004**
16.	RMBS-93-0-3	0.79	-1.46	0.011**	0.74	5.00	0.005**	0.81	0.53	0.0001	0.78	0.16	0.005**
17.	RMBS-93-3	0.83	3.70	0.006**	0.76	-5.96	0.001	0.84	1.21	-0.0000	0.81	0.57	0.005**
18.	RMBS-93-5-2	0.80	3.05	0.0002	0.73	3.48	0.008**	0.73	1.41	0.003**	0.75	1.01	0.004**
19.	Wardan	0.72	-0.63	0.025**	0.75	1.35	0.002**	0.79	1.06	0.001*	0.75	0.95	0.005**
20.	Mescavi	0.76	4.04	-0.0002	0.83	-6.94	-0.0000	0.76	0.48	0.0000	0.78	0.76	0.003**
	Mean	0.74			0.77			0.76			0.76		
	S.E.±	0.05	3.68		0.03	3.40		0.02	0.41		0.02	0.67	

Where, $\bar{X}$ = Mean, bi = Regression coefficient, S^2di = Mean square deviation
*, ** = Significant at P=0.05 and P=0.01, respectively.

mean and non-significant S^2di indicating its suitability for poor environment over three cuts in E_3.

4.1.2.5 **Green forage yield per plant**

Table 12, revealed that all the genotypes had significant $S^{-2}di$ in a set of environments indicating their unstability for this character. The genotypes BL-122 and JHB-93-2 in second environment (E_2) and JHB-92-4 in third environment (E_3) had `bi' value significantly higher than one with high mean performance and non-significant S^2di indicating below average stability i.e. suitability for rich environment. While, the genotype BL-130 in third environment (E_3) had bi value significantly less than one with high mean performance indicating above average stability i.e. suitability for poor environment.

The genotypes viz., JHB-93-3 and RMBS-93-0-1 in E_1, JHB-92-2, HFB-135, Wardan and Mescavi in E_2 and JHB-92-2, JHB-93-3, HFB-135 and Mescavi in E_3 had bi not significantly deviating from unity, non significant S^2di and mean performance higher than population mean indicating their wider adaptability in respective environments. In general, the genotypes, JHB-93-3 in E_1 and E_3, JHB-92-2, HFB-135 and Mescavi in E_2 and E_3 were common with general stability.

4.1.2.6 **Dry fodder yield per plant**

The stability parameters presented in Table 13, showed that all the genotypes over nine environments were unstable as they exhibited significant S^2di values. The

Table 12: Stability parameters (Eberhart and Russell, 1966) for green fodder yield per plant (g)

Sr. No.	Genotype	E_1			E_2			E_3			Nine Environments		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BL-102	23.13	0.38**	-0.002	31.28	0.97	0.382	24.66	0.99	-0.003	26.35	0.92*	6.129**
2.	BL-122	25.49	0.75	0.019	33.27	1.35*	1.149	28.54	1.14	15.969**	28.43	1.15	4.845**
3.	BL-126	21.65	0.65*	0.646*	26.11	0.65*	1.351**	22.49	1.19	3.568**	23.42	0.85	3.738**
4.	BL-130	23.72	1.99	0.659*	26.66	0.60*	0.567	25.29	1.18	-0.139	24.89	0.86	4.052**
5.	BL-131	25.49	0.84	1.174**	28.93	0.79	7.618**	23.89	0.91	0.522	26.10	0.84	2.210**
6.	JB-90-2-56	25.46	0.41**	8.849**	28.04	0.74	4.237**	28.01	0.70*	3.948**	26.50	0.60**	3.315**
7.	JB-92-1	25.33	1.04	0.339	29.88	0.76	2.084**	25.58	0.74*	0.111	26.93	0.82	1.959**
8.	JHB-92-2	28.41	0.90	0.900**	35.49	1.29	-0.084	28.41	1.05	-0.099	30.44	2.09	1.049**
9.	JHB-93-2	24.62	1.16	0.039	33.64	1.35*	-0.137	25.94	0.91	0.611*	28.06	1.19*	2.885**
10.	JHB-93-3	26.15	1.077	-0.125	30.27	0.93	1.994**	26.92	0.89	-0.060	27.78	0.91	0.916**
11.	JHB-93-4	32.88	1.33*	0.641*	40.83	2.49**	7.712**	32.79	1.31**	-0.113	35.50	1.39**	1.545**
12.	JHB-146	23.79	1.43*	17.865**	29.69	0.84	-0.093	25.29	1.13	2.289**	26.26	1.08	5.113**
13.	HPB-135	29.76	1.05	2.117**	35.89	1.17	-0.073	29.28	1.04	-0.136	31.64	2.09	0.583**
14.	RMBS-93-0-1	26.37	1.09	0.156	30.47	0.81	1.949*	25.51	1.05	1.3218**	27.45	0.95	1.337**
15.	RMBS-93-0-2	22.72	1.19	-0.125	29.13	0.71	-0.045	24.12	0.91	-0.139	25.33	0.94	1.636**
16.	RMBS-93-0-3	23.22	1.37*	-0.120	28.34	1.06	0.039	23.46	0.77	0.331	25.01	1.00	2.421**
17.	RMBS-93-3	25.20	1.25	-0.083	28.47	0.02	7.251**	24.76	1.01	0.268	26.14	1.00	2.833**
18.	RMBS-93-5-2	23.56	1.17	-0.110	29.21	0.98	3.285**	24.10	1.04	-0.128	26.63	1.04	0.593**
19.	Wardan	30.57	0.99	0.834*	38.33	1.29	0.322	30.85	1.02	0.907*	33.25	1.16	1.602**
20.	Mescavi	28.61	0.91	0.721*	35.19	1.17	-0.115	29.26	1.02	0.186	31.02	1.06	0.540**
	Mean	25.81			31.41			26.21			27.81		
	S.E.±	0.95	0.16		1.00	0.11		0.88	1.11		0.56	0.09	

Where, $\bar{X}$ = Mean, bi = Regression coefficient, S^2di = Mean square deviation
*, ** = Significant at P=0.05 and P=0.01, respectively.

Table 13: Stability parameters (Eberhart and Russell, 1966) for dry matter yield per plant

Sr. No.	Genotype	E_1			E_2			E_3			Nine Environments		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BL-102	4.42	0.84	0.504**	5.46	0.51**	0.105**	4.32	0.95	-0.001	4.73	0.84*	0.257**
2.	BL-122	4.78	0.95	0.645**	5.39	0.91	0.214**	4.66	1.00	0.002	4.94	0.96	0.040**
3.	BL-126	4.13	0.87	0.012*	4.73	0.99	0.156**	3.92	0.91	-0.003	4.26	0.93	0.034**
4.	BL-130	4.52	1.02	0.035**	4.51	1.08	0.155**	4.33	1.02	0.094**	4.45	1.00	0.128**
5.	BL-131	4.78	1.99	-0.0024	4.99	0.85	0.011	4.32	0.91	-0.003	4.70	0.92	0.038**
6.	JB-90-2-56	4.67	0.79	1.339**	4.96	0.84	0.036**	4.52	0.77**	0.018*	4.72	0.79**	0.062**
7.	JB-92-1	4.82	1.09	0.008	5.07	0.85	1.029**	4.55	0.86	0.034**	4.82	0.93	0.057**
8.	JHB-92-2	5.16	0.96	0.014*	5.95	1.02	-0.002	5.07	1.07	-0.001	5.39	1.03	0.017**
9.	JHB-93-2	4.71	1.02	-0.001	5.11	0.53**	0.171**	4.58	0.96	0.018*	5.79	0.87	0.128**
10.	JHB-93-3	4.99	1.03	-0.003	5.24	1.02	0.009	4.93	0.89	0.036**	5.05	0.95	0.045**
11.	JHB-93-4	5.74	1.20	0.094**	7.14	1.17	-0.002	5.81	1.25**	0.001	6.23	1.25**	0.123**
12.	JHB-146	4.63	1.17	0.0011	5.48	1.13	-0.002	4.55	1.07	0.059**	4.89	1.13	0.022**
13.	HFB-135	5.30	0.98	0.014*	5.99	1.42**	0.106**	5.31	1.14	0.033**	5.53	1.15*	0.099**
14.	RMBS-93-0-1	4.89	1.03	0.101**	5.09	0.96	0.041**	4.44	1.01	0.001	4.81	0.99	0.055**
15.	RMBS-93-0-2	4.46	1.99	0.012*	4.89	0.91	0.027**	4.48	0.93	0.131**	4.61	0.94	0.039**
16.	RMBS-93-0-3	4.57	1.02	0.167**	4.78	1.99	0.043**	4.47	0.95	0.003	4.61	0.96	0.067**
17.	RMBS-93-3	4.80	0.99	-0.0022	5.09	1.20	0.254**	4.54	1.01	-0.001	4.81	1.04	0.073**
18.	RMBS-93-5-2	4.47	0.93	0.030**	5.25	1.22	0.344**	4.50	1.07	0.185**	4.74	1.06	0.120**
19.	Wardan	5.63	1.13	0.107**	6.76	1.28	-0.002	5.64	1.15*	-0.002	6.041	1.20**	0.069**
20.	Mescavi	5.22	0.97	0.0005	6.10	1.08	0.045**	5.20	1.05	0.011*	5.51	1.05	0.031**
	Mean	4.81			6.399			4.71			4.98		
	S.E.±	0.11	0.11		0.14	0.14		0.13	0.07		0.099	0.07	

Where, $\bar{X}$ = Mean, bi = Regression coefficient, S^2di = Mean square deviation
*, ** = Significant at P=0.05 and P=0.01, respectively.

genotypes, JHB-93-4 and Wardan had b_i significantly higher than unity, high mean performance and non-significant S^2di in third environment (E_3) indicating their suitability for rich environment for this trait. The genotypes, JB-92-1, JHB-93-3 and Mescavi in first environment (E_1), JHB-92-2 in second (E_2) and third (E_3) and JHB-93-4, JHB-146 and Wardan in second environment (E_2) only had b_i not significantly deviating from unity, mean higher than population mean and non significant S^2di indicating their wider adaptability over cuts in respective environments for dry forage yield per plant.

4.1.2.7 **Crude protein content**

The Table 14, revealed that the genotype JHB-93-2 over nine environments and in first environment (E_1) was stable as it had non significant S^2di, 'b_i' at par with unity and higher mean performance than population mean for this trait. All the other genotypes, except BL-126, RMBS-93-0-1 and RMBS-93-0-3 over nine environments were unstable as they had significant S^2di. The above three genotypes, however, had lower mean performance with 'bi' at unity indicating their poor adaptability. In third environment (E_3), the genotypes, JHB-93-4 and Wardan had non significant S^2di, 'bi' significantly higher than unity, with high mean performance which indicated their below average performance i.e. suitability for rich environments. The genotypes <u>viz</u>., BL-131, JB-92-1, JHB-93-2, JHB-93-3 and HFB-135 in E_1 and BL-122 and JHB-93-3 in E_3 had wider adaptability in respective

Table 14: Stability parameters (Eberhart and Russell, 1966) for protein content yield

Sr. No.	Genotype	E_1			E_2			E_3			Nine Environments		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BL-102	0.83	0.85	0.039**	0.95	0.72	-0.0000	0.77	0.84	0.0003	0.85	0.84	0.007**
2.	BL-122	0.84	0.78	0.004	1.03	0.95	0.028**	0.85	0.93	-0.0001	0.91	0.91	0.007**
3.	BL-126	0.79	0.87	-0.002	0.87	0.93	0.0014*	0.70	0.87	0.001**	0.79	0.90	0.0004
4.	BL-130	0.82	0.88	0.007	0.80	0.91	0.001**	0.78	1.11	0.012**	0.80	0.93	0.006**
5.	BL-131	0.91	1.24	-0.001	0.89	0.84	-0.0000	0.76	1.02	0.006**	0.85	1.04	0.006**
6.	JB-90-2-56	0.87	1.05	0.011*	1.89	1.10	0.006**	0.75	0.92	-0.0000	0.84	1.02	0.004**
7.	JB-92-1	1.89	1.04	-0.0001	0.91	0.74	0.002**	0.79	0.68*	0.007**	0.87	0.82	0.004**
8.	JHB-92-2	0.98	0.97	-0.0002	1.08	0.92	0.004**	0.91	0.98	0.004**	0.99	0.98	0.001
9.	JHB-93-2	1.89	1.27	-0.001	0.94	0.73	0.015**	0.85	1.12	0.004**	1.89	1.04	0.006**
10.	JHB-93-3	0.92	1.26	-0.002	0.91	1.16	0.001**	1.89	0.82	0.0001	0.91	1.03	0.006**
11.	JHB-93-4	1.23	1.33	0.019**	1.38	1.37	0.001**	1.18	1.28*	0.0000	1.26	1.33	0.003**
12.	JHB-146	0.85	1.08	0.009**	1.02	0.94	0.015**	0.79	0.85	-0.0000	0.88	1.99	0.006**
13.	HFB-135	1.03	1.01	-0.0003	1.17	1.10	0.016**	1.99	1.03	0.003**	1.06	1.06	0.003**
14.	RMBS-93-0-1	0.79	0.89	-0.001	0.83	0.93	0.003**	0.76	1.99	0.0002	0.79	0.92	0.001
15.	RMBS-93-0-2	0.78	0.93	-0.007	0.86	0.87	0.0002	0.77	1.13	0.002**	0.81	0.97	0.001
16.	RMBS-93-0-3	0.79	1.07	0.021**	0.81	1.06	0.003**	0.77	0.95	0.001**	0.79	0.99	0.005**
17.	RMBS-93-3	0.84	0.95	0.001	0.90	1.14	0.021**	0.79	1.07	0.001**	0.85	1.03	0.004**
18.	RMBS-93-5-2	0.72	1.77	-0.002	0.90	1.09	0.030**	0.77	0.96	0.011**	0.79	0.94	0.009**
19.	Wardan	1.09	1.18	0.014**	1.30	1.58	0.0004**	1.12	1.27*	-0.0001	1.17	1.29	0.004*
20.	Mescavi	0.88	0.58	0.029**	1.13	1.08	0.001**	0.99	1.16	0.001**	1.00	0.95	0.016**
	Mean	0.89			0.98			0.85			0.91		
	S.E.±	23.19	0.22		0.06	0.22		0.00	0.12		0.03	0.10	

Where, $\bar{X}$ = Mean, bi = Regression coefficient, S^2di = Mean square deviation
*, ** = Significant at P=0.05 and P=0.01, respectively.

environments as they exhibited non significant S^2di, `bi' at unity and higher mean performance than population mean for crude protein content.

In second environment (E_2) all the genotypes except BL-102, BL-131 and RMBS-93-0-2 had significant S^2di values indicating their unstability for this trait in the above genotypes had mean performance less than population mean, `bi' values more or less unity indicating their poor adaptability.

4.1.2.8 Green fodder yield per meter distance

The stability parameter presented in Table 15, revealed that none of the genotypes, was stable for green fodder yield for meter distance over nine environments as they had significant S^2di.

The genotypes viz., JHB-92-2 and Mescavi, both in E_1 and E_2 environments, BL-122 and HFB-131 only in E_1 and the genotypes RMBS-93-0-3 and Wardan in E_3 had non significant S^2di, `b_i' values at par with unity and high mean performance than population mean indicating their general (wider) adaptability over respective environments for green forage yield per meter length.

4.1.3 Genotype x Environment (sowing time and fertilizer application) effect

Delay in sowing of berseem i.e. sowing in last week of December even with application of 20 kg N + 80 kg P_2O_5/ha as a basal dose + 10 kg N + 40 kg P_2O_5/ha after the

Table 15: Stability parameters (Eberhart and Russell, 1966) for green fodder yield per meter distance

Sr. No.	Genotype	E_1			E_2			E_3			Nine Environments		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di
1.	BL-102	377.22	0.15	1619.333**	464.44	0.96	390.049**	363.89	0.46*	367.643**	401.85	0.67	1633.123**
2.	BL-122	411.11	1.55	38.970	440.000	1.53	5.856	412.22	0.89	15.399	421.11	0.90	690.093**
3.	BL-126	401.67	1.15	409.379**	436.67	0.78	313.138**	368.89	0.78	879.706**	409.07	0.77	538.379**
4.	BL-130	293.33	1.55	1868.078**	322.22	1.53	2372.659**	298.89	0.82	3550.336**	304.81	0.86	1801.692**
5.	BL-131	416.67	1.10	1234.217**	479.44	0.64	2713.197**	440.55	1.19	726.530**	445.55	1.05	797.767**
6.	JB-90-2-56	363.89	1.19	1284.488**	470.55	1.09	325.132*	395.55	0.35**	1947.953**	410.00	0.66	1702.634**
7.	JB-92-1	356.11	2.39**	589.954**	446.11	1.58	6498.312**	414.44	0.96	416.200**	405.55	1.24	2324.516*
8.	JHB-92-2	439.44	1.13	55.320	570.00	0.58	55.178	451.67	1.22	171.393*	467.04	1.11	285.541**
9.	JHB-93-2	384.44	1.69	641.263**	500.55	0.62	2460.584**	413.33	1.10	91.513	432.78	1.27	931.992**
10.	JHB-93-3	376.11	0.77	768.667**	457.78	1.17	2178.948**	400.30	1.07	-28.181	412.41	1.05	453.186**
11.	JHB-93-4	512.78	1.51	4146.759**	635.00	0.85	644.894**	530.00	1.44	189.161*	559.26	1.48*	1080.113**
12.	JHB-146	352.22	-0.29*	-38.933	436.67	0.99	303.063**	380.00	0.56	3190.191**	389.63	0.62	1382.735**
13.	HFB-135	460.00	1.24	-24.922	542.22	0.76	454.695**	486.67	1.32	359.698**	497.29	1.22	200.253**
14.	RMBS-93-0-1	335.00	0.45	10.696	384.44	0.74	2277.550**	386.67	0.79	48.805	368.70	0.69	701.297**
15.	RMBS-93-0-2	343.89	1.33	48.310	435.55	1.68	102.497	400.00	1.42	-9.245	393.15	1.36	217.681**
16.	RMBS-93-0-3	323.33	1.89	1971.561**	405.55	1.17	311.544**	416.67	1.28	-18.097	381.85	1.14	1574.375**
17.	RMBS-93-3	356.11	0.24	156.110	382.78	0.85	75.737	382.22	0.74	-0.403	373.70	0.57*	327.403**
18.	RMBS-93-5-2	353.33	0.47	2148.446**	413.89	1.28	729.937**	357.78	0.87	4208.140**	375.00	0.84	1218.584**
19.	Wardan	480.00	2.19	1729.977**	577.78	0.51	171.479*	513.33	1.35	-25.519	523.70	1.27	456.675**
20.	Mescavi	448.89	1.25	30.674	522.78	0.69	5.505	474.44	1.38	401.017**	482.04	1.22	252.728**
	Mean	389.28			463.22			415.53			422.67	0.17	
	S.E.±	23.19	0.47		24.04	0.71		20.75	0.22		11.00		

Where, $\bar{X}$ = Mean, bi = Regression coefficient, S^2di = Mean square deviation

*, ** = Significant at P=0.05 and P=0.01, respectively.

first cut caused reduction in green as well as dry fodder yield, plant height, number of tillers per meter distance and crude protein content (Table 8 to 15) sowing of berseem in first week of December and application of 30 kg N + 120 kg P_2O_5/ha as a basal dose increased green and dry fodder yield, protein content, tillers per meter length and tillers per plant. The genotype JHB-93-4 was found to be superior over the check varieties Mescavi and Wardan for green fodder yield and other characters in all the environemnts.

4.2 Correlation studies

The genotypic and phenotypic correlation coefficients for eight characters studied over three environments for second cut (being most representati ve of the performance) are presented in Table 16 to 18, the only significant correlations are described. In general, genotypic correlation coefficients were of higher magnitude than their corresponding phenotypic correlation coefficients in all the three environments.

4.2.1 Association of green fodder yield per meter distance with its components

It is releaved from Table 16 to 18 that green forage yield had high significant positive genotypic and phenotypic correlations with the plant height, number of tillers per plant and per meter distance, green fodder yield per plant, dry fodder yield and crude protein content, in all the three environments. It however, showed non significant negative correlation with leaf/stem ratio in E_1 and E_2

environments, while, non significant positive correlation with leaf/stem ratio in E_3 environment.

4.2.2 *Inter se* associations of the green forage yield components and related traits

In E_1 environment, plant height showed positively significant association only with green fodder yield at both genotypic and phenotypic levels, whereas, it showed positive and highly significant association with number of tillers per plant, green fodder yield per plant, dry fodder yield per plant, crude protein content and green fodder yield per meter distance in E_2 and E_3 environments. Further, it showed highly significant positive association with number of tillers per meter distance at both the levels in E_2 environment.

Number of tillers per plant had positively and highly significant correlations with green fodder yield per plant, dry fodder yield per plant, crude protein content and green fodder yield per meter distance at both, genotypic and phenotypic levels in all the environments. It also showed positive and highly significant association with number of tillers per meter distance at both the levels in E_1 and E_2 environments.

Number of tillers per meter distance had positive and highly significant correlation with dry fodder yield per plant and green fodder yield per meter distance at both the levels in E_1 and E_2 environments, whereas, it had positively

Table 16 : Genotypic (G) and Phenotypic (P) correlation coefficients for first environment (Cat-2)

Sr. No.	Character		1	2	3	4	5	6	7	8
1.	Plant height	G	1.000	0.233	0.136	-0.148	0.219	0.227	0.290	0.335*
		P	1.000	0.297	0.130	-0.066	0.197	0.222	0.273	0.309*
2.	Number of tillers/	G		1.000	0.701**	0.097	0.941**	0.865**	0.774**	0.665**
	plant	P		1.000	0.486**	0.032	0.650**	0.601**	0.537**	0.442**
3.	Number of tillers/	G			1.000	-0.186	0.408**	0.488**	0.608**	0.770**
	meter length	P			1.000	-0.152	0.389*	0.463**	0.580**	0.760**
4.	L/S ratio	G				1.000	0.181	0.045	-0.037	-0.154
		P				1.000	0.166	0.048	-0.023	-0.122
5.	Green fodder yield/	G					1.000	0.955**	0.813**	0.512**
	plant (GFY)	P					1.000	0.937**	0.800**	0.496**
6.	Dry fodder yield/	G						1.000	0.881**	0.600**
	plant (DFY)	P						1.000	0.880**	0.589**
7.	Crude protein content	G							1.000	0.749**
		P							1.000	0.736**
8.	Green fodder yield/	G								1.000
	meter distance (GFY)	P								1.000

* and ** significant at P=0.05 and 0.01, respectively.

Table 17 : Genotypic (G) and Phenotypic (P) correlation coefficients for second environment (Cut-2)

Sr. No.	Character		1	2	3	4	5	6	7	8
1.	Plant height	G	1.000	0.816**	0.680**	-0.110	0.442**	0.542**	0.486**	0.743**
		P	1.000	0.759**	0.665**	-0.099	0.439**	0.536**	0.372*	0.734**
2.	Number of tillers/ plant	G		1.000	0.570**	-0.077	0.662**	0.546**	0.576**	0.788**
		P		1.000	0.507**	-0.094	0.617**	0.510**	0.467**	0.720**
3.	Number of tillers/ meter length	G			1.000	-0.266	0.399**	0.408**	0.445**	0.633**
		P			1.000	-0.227	0.389*	0.393**	0.379*	0.623**
4.	L/S ratio	G				1.000	-0.109	-0.236	-0.249	-0.180
		P				1.000	-0.099	-0.214	-0.178	-0.156
5.	Green fodder yield/ plant (GFY)	G					1.000	0.809**	0.889**	0.779**
		P					1.000	0.806**	0.717**	0.768**
6.	Dry fodder yield/ plant (DFY)	G						1.000	0.999**	0.702**
		P						1.000	0.805**	0.689**
7.	Crude protein content	G							1.000	0.717**
		P							1.000	0.570**
8.	Green fodder yield/ meter distance (GFY)	G								1.000
		P								1.000

* and ** significant at P=0.05 and 0.01, respectively.

Table 18 : Genotypic (G) and Phenotypic (P) correlation coefficients for third environment (Cut-2)

Sr. No.	Character		1	2	3	4	5	6	7	8
1.	Plant height	G	1.000	0.819**	0.190	0.141	0.733**	0.597**	0.602**	0.493**
		P	1.000	0.672**	0.170	0.059	0.664**	0.542**	0.549**	0.460**
2.	Number of tillers/ plant	G		1.000	0.243	0.051	0.835**	0.808**	0.770**	0.707**
		P		1.000	0.184	-0.056	0.673**	0.639**	0.612**	0.568**
3.	Number of tillers/ meter length	G			1.000	-0.047	0.061	0.046	0.121	0.448**
		P			1.000	-0.028	0.069	0.042	0.116	0.446**
4.	L/S ratio	G				1.000	0.279	0.300	0.228	0.290
		P				1.000	0.266	0.272	0.208	0.246
5.	Green fodder yield/ plant (GFY)	G					1.000	0.920**	0.890**	0.645**
		P					1.000	0.907**	0.881**	0.635**
6.	Dry fodder yield/ plant (DFY)	G						1.000	0.920**	0.714**
		P						1.000	0.920**	0.698**
7.	Crude protein content	G							1.000	0.744**
		P							1.000	0.731**
8.	Green fodder yield/ meter distance (GFY)	G								1.000
		P								1.000

* and ** significant at P=0.05 and 0.01, respectively.

significant association only with green fodder yield per meter distance at both the levels in E_3 environments. It also showed positively significant association with green fodder yield per plant and crude protein content at both the levels in E_1 and E_2 environments.

L/S ratio had non significant but positive correlation with green fodder yield and dry fodder yield per plant in E_1 and E_3 environments, while its correlation with all the traits in E_2 was non significant and negative. Its association with crude protein content was non significant and negative in E_1 and non significant positive in E_3 environment. The association of L/S ratio with green fodder yield per meter distance was non significant and negative in E_1 and E_2, while it was non significant but positive in E_3 environment.

Green fodder yield per plant had positively significant correlations with dry fodder yield per plant, crude protein content and green fodder yield per meter distance at both, genotypic and phenotypic levels in all the environments.

Dry fodder yield per plant also had positive and highly significant association with crude protein content and green fodder yield per meter distance at both the levels in all the environments.

Crude protein content showed positive and highly significant association with green fodder yield per meter distance at both genotypic and phenotypic levels in all the environments (E_1, E_2 and E_3).

4.3 Path coefficient analysis

The genotypic correlation is due to common genetic factors responsible for the inheritance of the trait in question, hence indicates inherant relationship. The path coefficient analysis is therefore, extended to genotypic path only to know the direct and indirect genotypic effects of each yield contributing characters on green fodder yield per meter distance. The path coefficients thus computed at E_1, E_2 and E_3 environments (second cut) separately for eight characters are presented in Table 16, 17 and 18, respectively.

4.3.1 Green fodder yield per meter distance Vs. plant height

In E_1 environment (sowing in first week of December with 20 kg N + 80 kg P_2O_5/ha as basal dose) plant height had low positive direct effect (0.158) on green fodder yield per meter distance. It had negative indirect effect through number of tillers per plant and dry matter yield per plant. Its indirect effects through green fodder yield per plant, number of tillers per meter distance and crude protein content were positive (Table 19).

In E_2 environment (sowing in first week of December with 30 kg N + 120 kg P_2O_5/ha as basal doses, it had high positive direct effect (0.511) on green fodder yield per

Table 19 : Direct-Indirect effects for genotypic path for first environment

Sr. No.	Character		1	2	3	4	5	6	7	Total genotypic correlation with GFY/mt.dist.
1.	Plant height	G	0.158	-0.068	0.087	0.001	0.057	-0.032	0.132	0.335*
2.	Number of tillers/ plant	G	0.037	-0.293	0.448	-0.001	0.244	-0.123	0.353	0.665**
3.	Number of tillers/ meter length	G	0.022	-0.206	0.639	0.001	0.106	-0.069	0.277	0.770**
4.	L/S ratio	G	-0.023	-0.029	-0.119	-0.006	0.047	-0.006	-0.017	-0.154
5.	Green fodder yield/ plant (GFY)	G	0.035	-0.276	0.266	-0.001	0.259	-0.136	0.371	0.512**
6.	Dry fodder yield/ plant (DFY)	G	0.036	-0.254	0.312	0.000	-0.247	-0.142	0.402	0.600**
7.	Crude protein content	G	0.046	-0.227	0.389	0.000	0.210	-0.125	0.456	0.749**

** = Significant at P=0.01. Residual effect : 0.26.

Table 20 : Direct-Indirect effects for genotypic path for second environment

Sr. No.	Character		1	2	3	4	5	6	7	Total genotypic correlation with GFY/mt.dist.
1.	Plant height	G	0.511	-0.007	0.044	0.005	0.222	-0.254	0.221	0.743**
2.	Number of tillers/ plant	G	0.417	-0.008	0.037	0.004	0.331	-0.256	0.262	0.788**
3.	Number of tillers/ meter length	G	0.348	-0.005	0.065	0.013	0.200	-0.191	0.203	0.633**
4.	L/S ratio	G	-0.056	0.001	-0.017	-0.050	-0.054	0.111	-0.113	-0.180
5.	Green fodder yield/ plant (GFY)	G	0.226	-0.005	0.026	0.005	0.501	-0.379	0.405	0.779**
6.	Dry fodder yield/ plant (DFY)	G	-0.277	-0.005	0.027	0.012	0.405	-0.469	0.455	0.702**
7.	Crude protein content	G	0.248	-0.005	0.029	0.012	0.445	-0.469	0.455	0.717**

** = Significant at P=0.01. Residual effect : 0.19.

Table 21 : Direct-Indirect effects for genotypic path for third environment

Sr. No.	Character		1	2	3	4	5	6	7	Total genotypic correlation with GFY/mt.dist.
1.	Plant height	G	-0.199	0.478	0.058	0.035	-0.286	0.069	0.338	0.493**
2.	Number of tillers/ plant	G	-0.163	0.583	0.074	0.013	-0.326	0.093	0.433	0.707**
3.	Number of tillers/ meter length	G	-0.038	0.142	0.306	-0.012	-0.024	0.005	0.068	0.448**
4.	L/S ratio	G	-0.028	0.030	-0.014	0.249	-0.109	0.035	0.128	0.290
5.	Green fodder yield/ plant (GFY)	G	-0.146	0.487	0.019	0.069	-0.390	0.106	0.500	0.645**
6.	Dry fodder yield/ plant (DFY)	G	-0.119	0.471	0.014	0.075	-0.359	0.115	0.517	0.714**
7.	Crude protein content	G	-0.120	0.449	0.037	0.057	-0.347	0.106	0.562	0.744**

** = Significant at P=0.01. Residual effect : 0.23.

meter distance. Its indirect effects through number of tillers per meter distance, green fodder yield per plant, L/S ratio and crude protein content were also positive. However, its indirect effects through dry matter yield per plant and number of tillers per plant were negative (Table 20).

In E_3 environment (sowing in last week of December with 20 kg N + 80 kg P_2O_5/ha as a basal dose plus 10 kg N + 40 kg P_2O_5/ha after the first cut), this character exhibited negative direct effect (-0.199) on green fodder yield per meter distance. However, indirect effects of plant height through all the characters except green fodder yield per plant were positive with the highest contribution (0.478) through number of tillers per plant (Table 21).

4.3.2 Green fodder yield per meter distance Vs. number of tillers per palnt

Number of tillers per plant had negative direct effect on green fodder yield (-0.293) in E_1 and (-0.008) in E_2 environments while, it had high positive direct effect on green fodder yield (0.583) in E_3 environment. Its indirect effects through dry matter yield per plant both in E_1 and E_2 environments, through L/S ratio in E_1 and through plant height and green fodder yield per plant in E_3 were also negative. However, indirect effects of number of tillers per plant through number of tillers per meter distance, green fodder yield per plant, crude protein content and plant height in E_1 environment, though green fodder yield per plant, number of tillers per meter distance, plant height, crude protein content and L/S ratio in E_2 environment and through number of tillers per meter distance, L/S ratio, dry fodder yield per plant and crude protein content in E_3 environment were positive.

4.3.3 Green fodder yield per meter distance Vs. number of tillers per meter distance

Number of tillers per meter distance had positive and high direct effect in E_1 (0.639) and in E_3 (0.306), while low in E_2 (0.065) on green fodder yield per meter distance. Similarly, its indirect effects through L/S ratio, green fodder yield per plant, crude protein content and plant height were also positive in E_1 and E_2 environments. In E_3 environment, its indirect effects through number of tillers per plant, crude protein content and dry fodder yield were positive. However, indirect effects of this trait through number of tillers per plant and dry fodder yield per plant in both E_1 and E_2 environments, were negative.

4.3.4 Green fodder yield per meter distance Vs. L/S ratio

The direct effect of L/S ratio on green fodder yield per meter distance was negative and low in E_1 (-0.006) and in E_2 (-0.050), while, it was positive in E_3 environment (0.249). Similarly, its indirect effects through all the characters except green fodder yield per plant in E_1 and number of tillers per plant and dry fodder yield in E_2 were also negative. In E_3 environment, its indirect effect through number of tillers per plant, dry fodder yield and crude protein content were positive. However, indirect effects through green fodder yield per plant, plant height and number of tillers per meter distance were negative.

4.3.5 Green fodder yield per meter distance Vs. green fodder yield per plant

The green fodder yield in E_1 and E_2 environments, had positive and medium to high direct effects (0.259 and 0.501, respectivley) on green fodder yield per meter distance. However, it had negative and high direct effect (-0.390) on green fodder yield per meter distance in E_3 environment.

Similarly, its indirect effects through plant height, number of tillers per meter distance and crude protein content were also positive in E_1 and E_2 environments, while those via number of tillers per plant, dry fodder yield and L/S ratio in E_1 and via dry fodder yield and number of tillers per plant in E_2 were negative. Indirect effects of this trait in E_3 environment through all the characters except plant height were positive. In general, the highest influence of green fodder yield per plant was through crude protein content in all the environments.

4.3.6 Green fodder yield per meter distance Vs. dry fodder yield per plant

The direct effect of dry fodder yield per plant was negative in E_1 (-0.142) and in E_2 (-0.469) environments. However, it was positive (0.115) in E_3 environment. Indirect effects of dry matter yield per plant through all the characters except number of tillers per plant and green fodder yield per plant in E_1 environment, number of tillers per meter distance in E_2 environment and except plant height and green fodder yield per plant in E_3 environment were positive. The highest influence of dry fodder yield per plant was *via* crude protein content in all the environments.

4.3.7 Green fodder yield per meter distance Vs. crude protein content

Crude protein content had positive and high direct effect on green fodder yield per meter distance in E_1 (0.456), in E_2 (0.455) and in E_3 (0.563). Similarly, its indirect effects through all the characters except number of tillers per plant and dry fodder yield in E_1 and E_2 environments were also positive. However, its indirect effects in E_3 environment through plant height and green fodder yield per plant were negative. The indirect effect of this trait through number of tillers per plant in E_3 environment was positive and the highest (0.449) while in E_1 and E_2 environments it was negative (-0.22 and -0.005, respectively.

The residual path effects in E_1, E_2 and E_3 environments were 0.26, 0.19 and 0.23, respectively.

DISCUSSION

5. DISCUSSION

In the present investigation, twenty genotypes of berseem (*Trifolium alexandrinum* L.) were studied through the analysis of genotype x environment interaction and stability parameters. The results have been presented in chapter four and are discussed here under appropriate headings.

5.1 Genotype x Environment interactions and stability parameters

Plant breeding is said to be the management to genetic variability. Plant breeders look for a greater variability in crop plants and aim at evolving strains which may give maximum economic yield over environments and show consistent performance. However, the same can be inferred from phenotype, which is the linear function of genotype, environment and interaction of both. Phenotype usually gets changed when a genotype is grown over varying environments. It has been shown that G x E interaction is widely present and contributes substantially to the nonrealization of expected gains from selection (Comstock and Moll, 1963). A population which can adjust its genotypic or phenotypic state in response to environmental fluctuations in such a way that it gives high and stable economic returns can be termed as 'well buffered' (Singh and Singh, 1980). Allard and Bradshaw (1964) have critically reviewed this phenomenon and have brought out its implications in applied plant breeding.

Genotype x Environment interaction certainly plays an important role in the evaluation and execution of breeding programmes. Thus, G x E interaction is important in the expression of quantitative characters which are controlled by polygenic system and are largely influenced by the environmental fluctuations.

Various methods have been proposed for statistical analysis of G x E interactions from time to time. Growing a set of genotypes under a large number of environments and combined analysis proved to be useful in assessing the presence of G x E interaction. However, it did not go any further towards dynamic interpretation of the stability of individual genotype. The most widely used approach in this respect is the regression technique in which G x E interaction component of variance is partitioned into its linear and non-linear portion for assessing the stability of genotypes over a range of environments. This is known as a joint regression analysis. In the present study, the same approach as outtined by Eberhart and Russell (1966) has been used.

5.1.1 Analysis of variance

The significance of genotypic diferences for the individual cahracters in all the environments suggested substantial variability in the genotypes evaluated (Table 3 to 6). The pooled mean differences due to genotypes were significant for all the characters in all the environments and also in three environments when tested against G x E interaction. Similarly, the mean differences among the genotypes were found to be significant for all the characters in all the environments when tested against pooled deviation except L/S ratio in first (E_1) environment. Environmental variances were highly significant for all the characters except L/S ratio in E_1 and E_2 environments, which indicated presence of sufficient variability among the genotypes and even over environments. Presence of G x E interaction for all the characters in all the sets of environments suggested varying responses of genotypes to different environments. Krab et al. (1986) also observed significant G x E interactions for forage yield when thirteen barseem varieties were evaluated over five environments indicating differences in their stability. The linear component of G x E interaction was significant for plant height in E_1, E_2 and overall the environments, number of tillers per plant only in E_1, number of tillers per meter distance in E_2, E_3 and over all environments, green forage yield per plant in E_1, E_2 and over all environments, dry forage yield per plant in both three and nine environments and for green fodder yield per meter distance in E_1, E_3 and over nine environments indicating significant differences among the genotypes for their regression on environmental indices for these traits in respective set of environments. The non-linear component (pooled deviation) was also highly significant for all the characters in all the environments except number of tillers per plant in first environment (E_1) indicating that part of the variation in the performance of the genotypes is unpredictable and both linear regression and deviations from linearity were the major components for differences in stability for the above characters. However, the G x E (L) component was of higher magnitude for plant height, number of tillers per meter distance and green fodder yield per meter distance and green fodder yield per meter distance in most of the environments indicating the important role of linear effect in the development of these characters. Khatri and Jatasra (1991) and Khari et al. (1992) also observed significant linear and non-linear components of G x E interactions for green and dry fodder yield in berseem.

5.1.2 **Stability parameters**

Finlay and Wilkinson (1963) considered linear regression slope (b) as a measure of stability. Further, Eberhart and Russell (1966) emphasised the need of both 'bi' deviation from regression and 'S^2di' in evaluating the genotypes for phenotypic stability by measuring G x E interactions. Paroda and Hayes (!971) stressed that linear regression of the variety be considered for evaluating the potential, whereas, the deviation around the regression gives a measures of stability of the genotypes over environments. Bains and Gupta (1972) proposed that the most stable genotype would be one which has high mean performance and regression coefficient not deviating significantly from zero as well as deviation mean square approching to zero. They further proposed that the genotypes with mean yield less than the grand mean be considered as poorly adapted irrespective of their regression coeficient and deviation mean squares. The progenies where the performance was within the range of grand mean (GM ± SE) were considered as having low stability while, those having mean performance higher than this values were classified having high or average stability. Considering all the above points, in the present study the genotypes having atleast mean performance greater than population mean and S^2di low or non significant and (i) `bi' approaching to unity or non significantly deviating from unity are regarded with general stability (ii) `b_i' significantly greater than unity are considered adapted to favourable environments and (iii) `b_i' significantly less than unity, has been classified as adapted to poor environments. The genotypes with significant S^2di have been stated as unstable (Patil, 1985).

The stability parameters presented in Table 8 to 15 helped to identify the genotypes promising for yield and its components and suitable for varying environmental conditions.

The environmental indices for eight characters for which stability parameters were worked out revealed (Table 7) that first cut of berseem in general as the most favourable as it exhibited positive and the highest environmental indices for almost all the important characters except for green fodder yield per plant in E_2 and plant height in E_3 environment. The highest negative values in second cut for all the environments (E_1, E_2 and E_3) for most of the characters graded these environments as most unfourable for the traits studied. While, third cut was fourable for plant height, number of tillers per meter distance in E_1 and E_3, green fodder yield per plant and per meter distance in all environments.

Yield is the end product which depends on the number of traits. Stability in yield, therefore, depends on holding certain morphological and physiological attributes steady and allowing others to vary resulting in G x E interaction for ultimate character i.e. yield (Patil, 1985). The successful evaluation of stable genotypes which could be used in further breeding programmes to develop stable and promising genotypes can be done through the study of G x E interaction. The study of stability in yield components in this respect, therefore, is of immense importance. The results of the present investigation conducted in this direction are narrated below.

The summary of nature of adaptability based on stability parameters estimated is presented in Table 22.

5.1.2.1 Plant characters

For plant height, the genotype JHB-93-3 was observed adaptable to all the environments. Further, the genotypes, BL-122 and BL-131 in the first environment (E_1). Only JB-92-1, JHB-92-2, JHB-146, HFB-135 and Mescavi both in E_1 and E_2 envirnments and JHB-93-2, JHB-93-4 and Wardan in E_3

environment had wider adaptability for plant height. Significant G x E interaction, environment (linear) and pooled deviation for plant height indicated that predication about the performance of this trait is rather difficult as the non linear component of G x E interaction is significant.

5.1.2.2 **Yield components**

For number of tillers per plant, the genotypes JHB-92-2, JHB-93-4, HFB-135, Wardan and Mescavi had wider adaptability over cuts in three environments as well as over all environments. However, the genotypes RMBS-93-0-3 and RMBS-93-3 had wider adaptability for this trait only in E_1 environment. However, the genotypes BL-122 and JB-92-1 had wider adaptability only in E_2 environment and BL-131 and JHB-93-2 exhibited wider adaptably only in E_3 environment. The genotype, BL-126 exhibited specific adaptibility to rich environment in the set of second environment (E_2).

BL-126 was observed adaptable to rich environment for number of tillers per meter distance in third environment (E_3) while, it had general adaptability in E_2 environment. All the genotypes in E_1 environment except BL-122 were unstable for this trait as they had significant S^2di values. The genotype BL-122 had bi=1, non significant S^2di but mean performance was lower than population mean. The other genotypes, BL-131, JHB-93-2, RMBS-93-5-2 in E_2 environments, while, Wardan, RMBS-93-0-3, HFB-135 and JHB-93-4 in E_3 environments exhibited wider adaptability. The genotypes JHB-92-2 and Mescavi had wider adaptability in both E_2 and E_3

environments. However, none of the genotypes exhibites wider or specific adaptability for number of tillers per meter distance over all the environments.

For green fodder yield per plant, the genotypes, BL-122 and JHB-93-3 in E_2 and JHB-93-4 in E_3 environments were observed adaptable to rich environment, while the genotype BL-130 in E_2 environment had above average stability i.e. favourable to poor environment. The other genotypes, JHB-93-3 in E_1 and E_3 environments, JHB-92-2, HFB-135 and Mescavi both in E_2 and E_3 environments while, Wardan only in E_2 and RMBS-93-01 only in E_1 environments had wider adaptability for green fodder yield per plant. However, none of the genotypes for this trait exhibited specific or wider adaptability over all the environments due to significant S^2di values. For dry fodder yield per plant, the genotypes, JHB-93-4 and Wardan had below average stability in E_3 environment, while they showed wider adaptably in E_2 environment. In E_1 environments, JB-92-1, JHB-93-3 and Mescavi had wider adaptability, while JHB-92-2 in E_2 and E_3 environments and JHB-146 only in E_2 environment, were observed with general adaptablity. However, none of the genotypes exhibited general or specific adaptability over all the environments for this trait (Fig. 1 to 4).

For green fodder yield per meter distance the genotypes, BL-122 and HFB-131 in E_1 environments JHB-92-2 and Mescavi in both E_1 and E_2 environments while RMBS-93-0-3 and

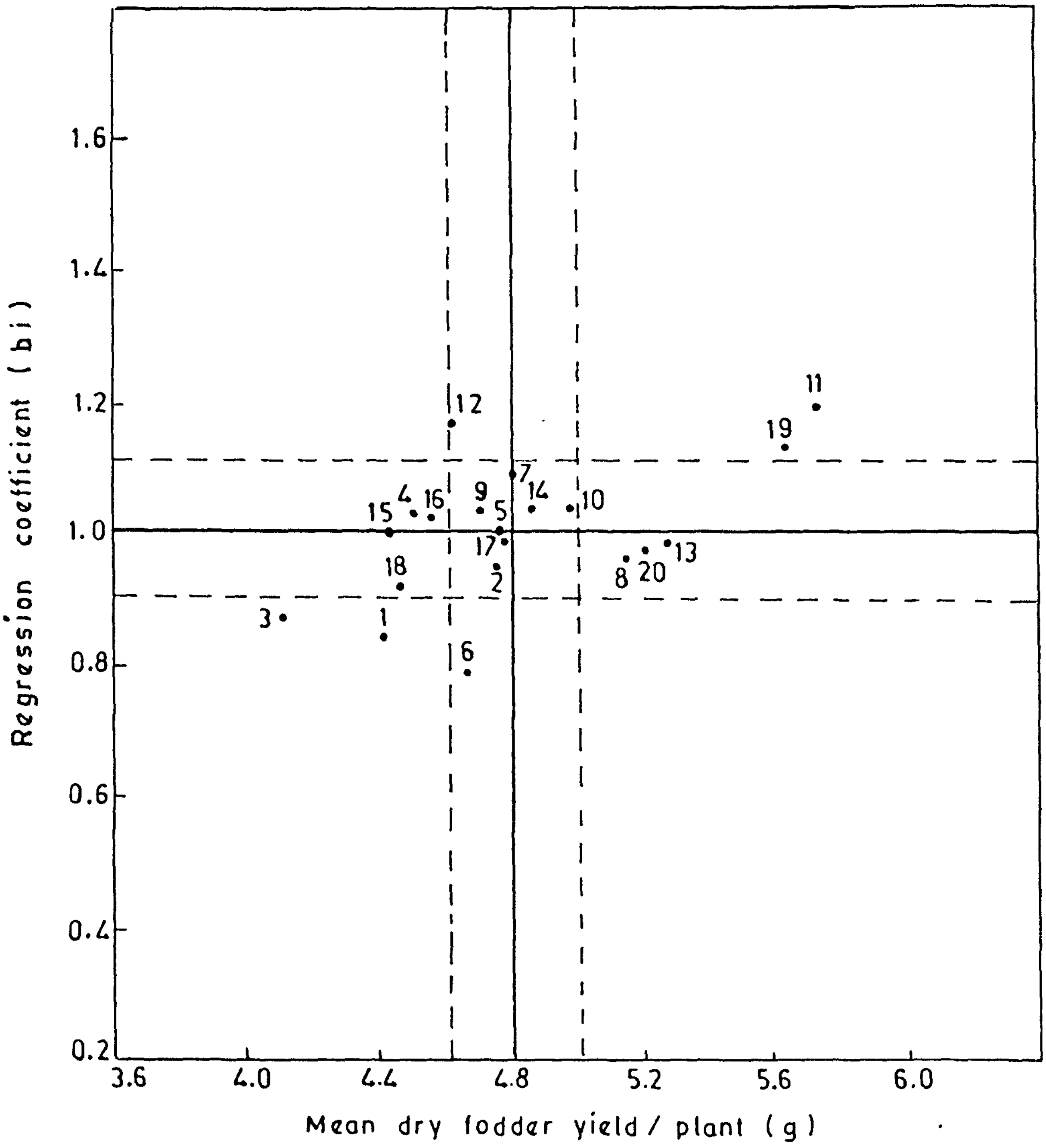


Fig. 1 Relation of dry fodder yield/plant and stability (E_1 environment)

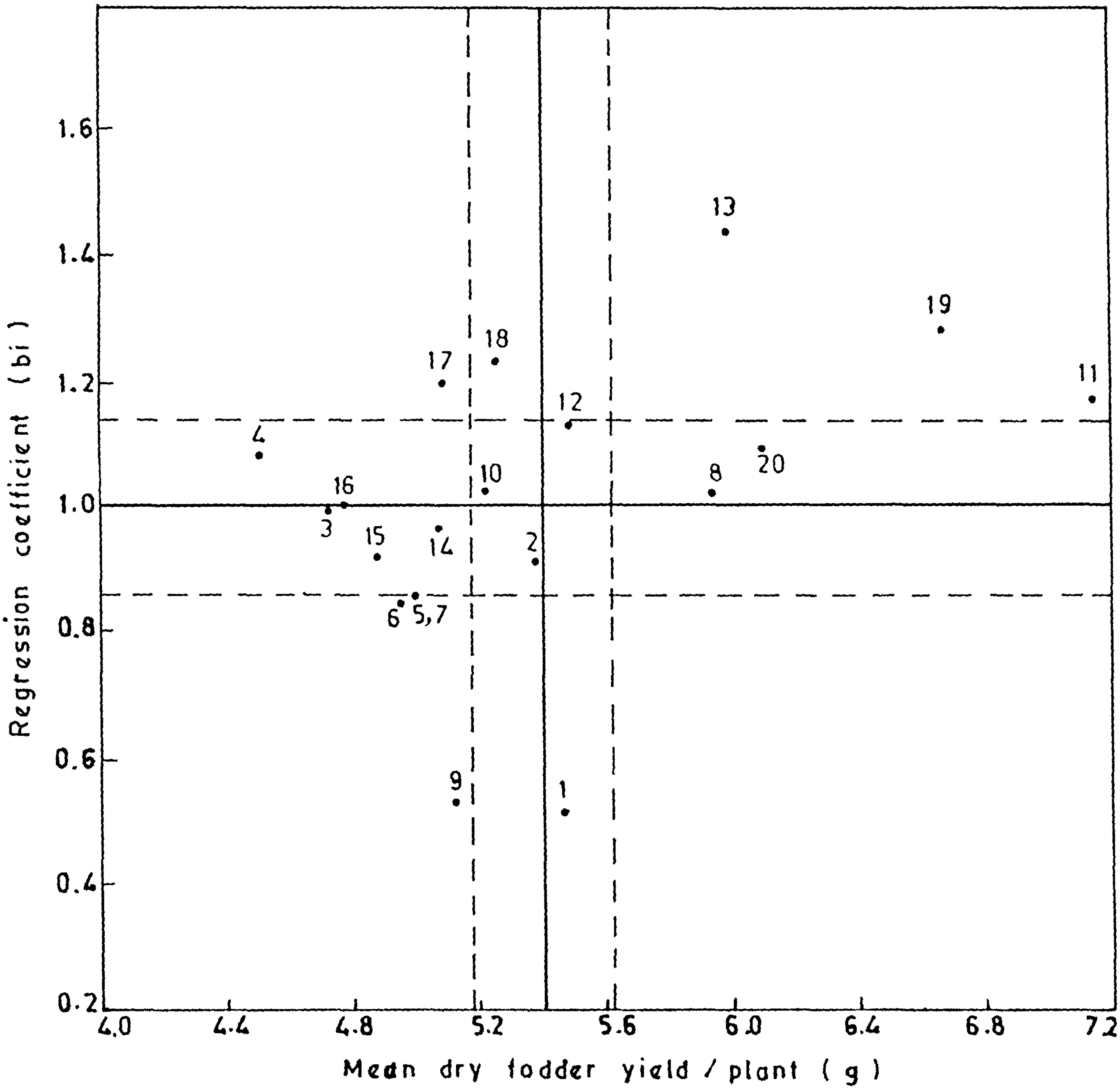


Fig. 2 Relation of dry fodder yield/plant and stability
(E_2 environment)

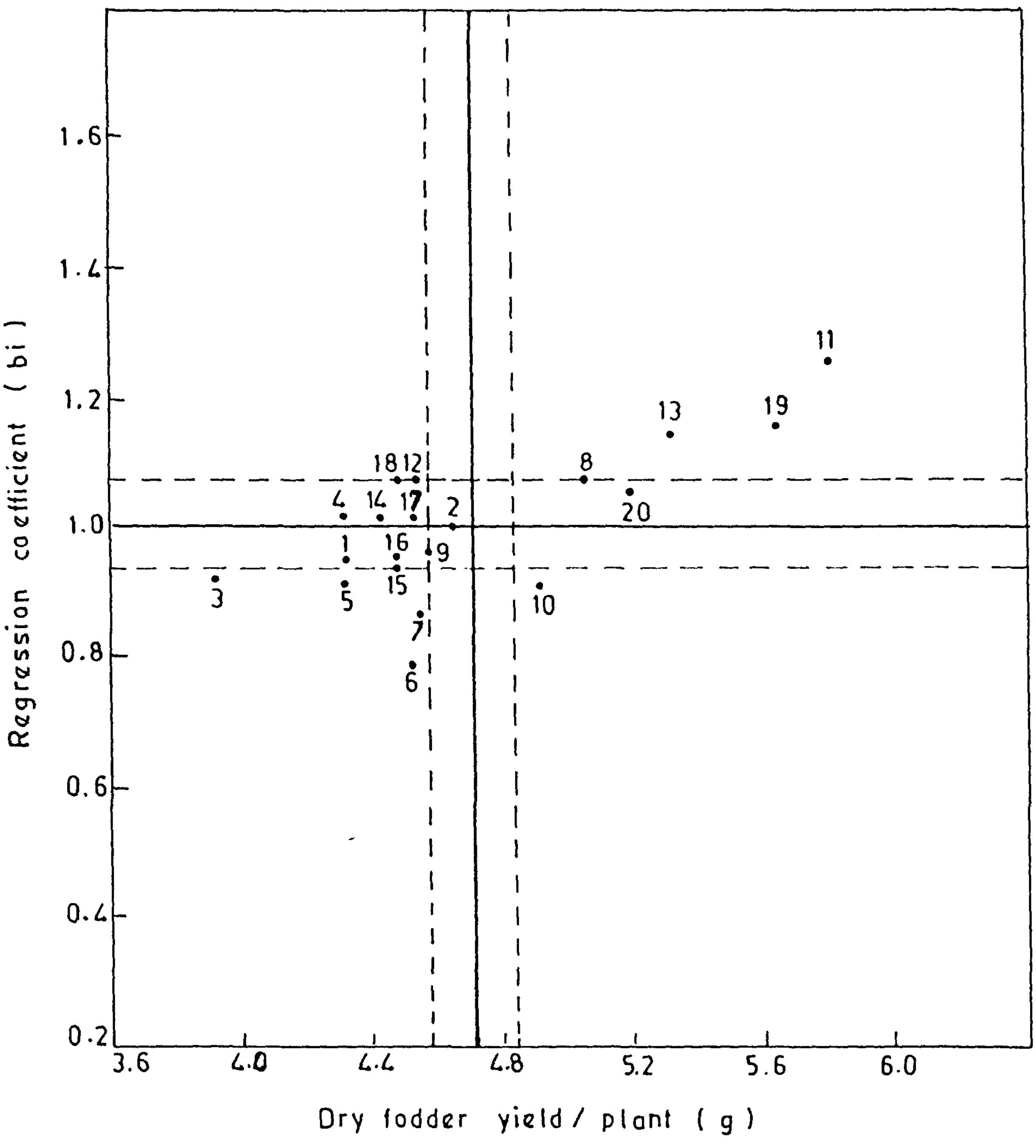


Fig. 3 Relation of dry fodder yield/plant and stability
(E_3 environment)

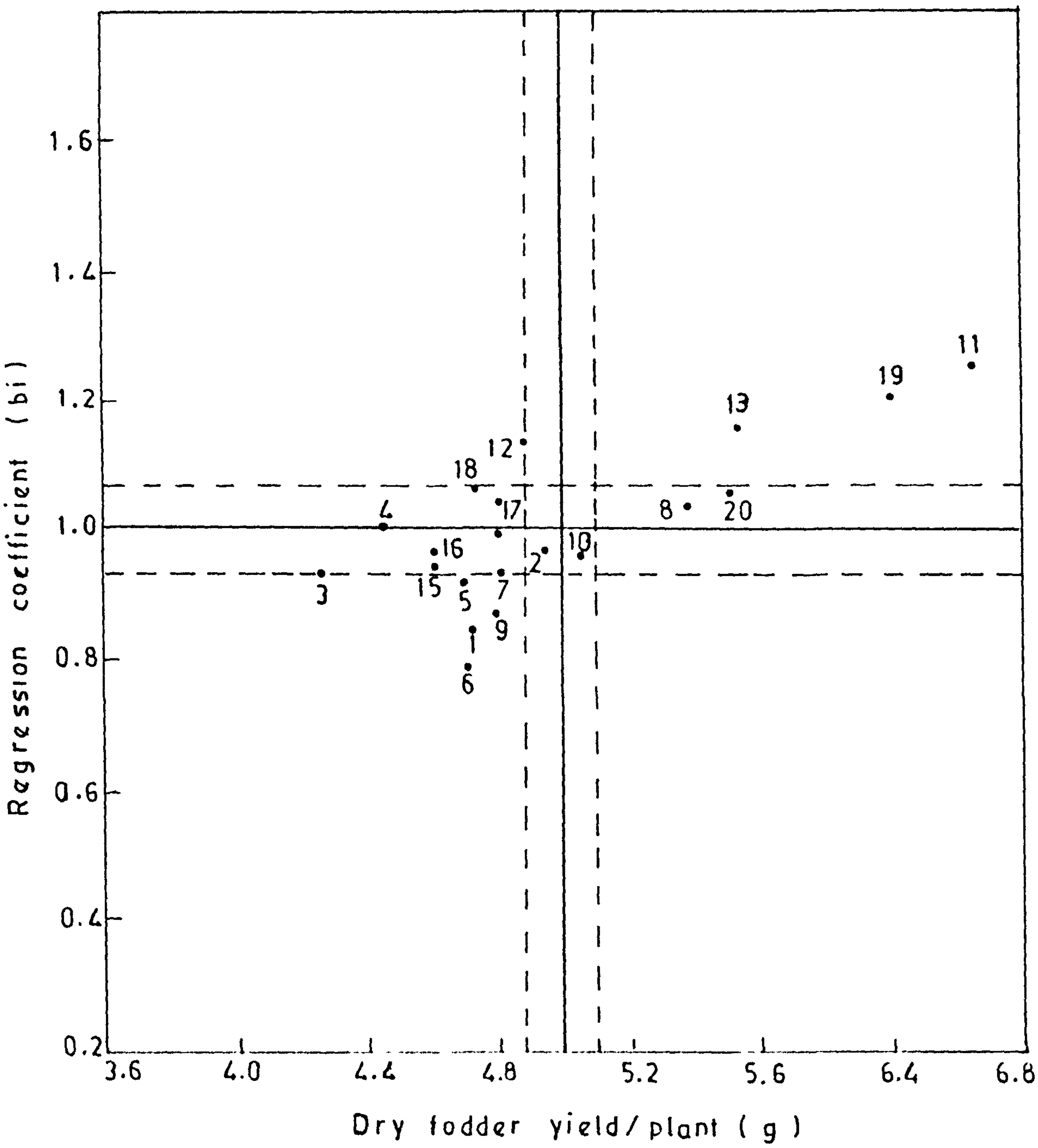


Fig. 4 Relation of dry fodder yield/plant and stability
(Pooled)

Wardan in E_3 environment had wider adaptability for this trait (Fig. 5 to 7). However, none of the genotypes was found stable over all environments due to significant S^2di values.

The G x E interaction and pooled deviation were found to be significant for number of tillers per plant (except in E_1 non significant pooled deviation) number of tillers per meter distance, green fodder yield, dry fodder yield per plant and green fodder yield per meter distance which indicated that prediction of the performance of these traits was rather difficult. However, both linear and non linear components of G x E interaction played significant role in the expression of dry and green fodder yield per plant and per meter distance in almost all the environments suggesting atleast prediction of the performance of genotypes is partly possible in respect of these traits. Khari et al. (1992) also reported that both linear and non linear components of G x E interaction were present for both green and dry fodder yield in berseem.

5.1.2.3 Quality characters

For L/S ratio the genotype Mescavi in E_2 was favourable for rich environment, while in E_3 BL-102 was favourable to poor environment. Further, the genotypes, Mescavi in E_1 and E_3, JHB-146 in E_2 and E_3 had wider adaptability. While, the genotypes JHB-93-2, JHB-93-4, RMBS-93-0-1, RMBS-93-0-2 and RMBS-93-5 in E_1, BL-122, BL-126 and JB-92-1 in E_2 and the genotypes, RMBS-93-0-3 and RMBS-93-3 in

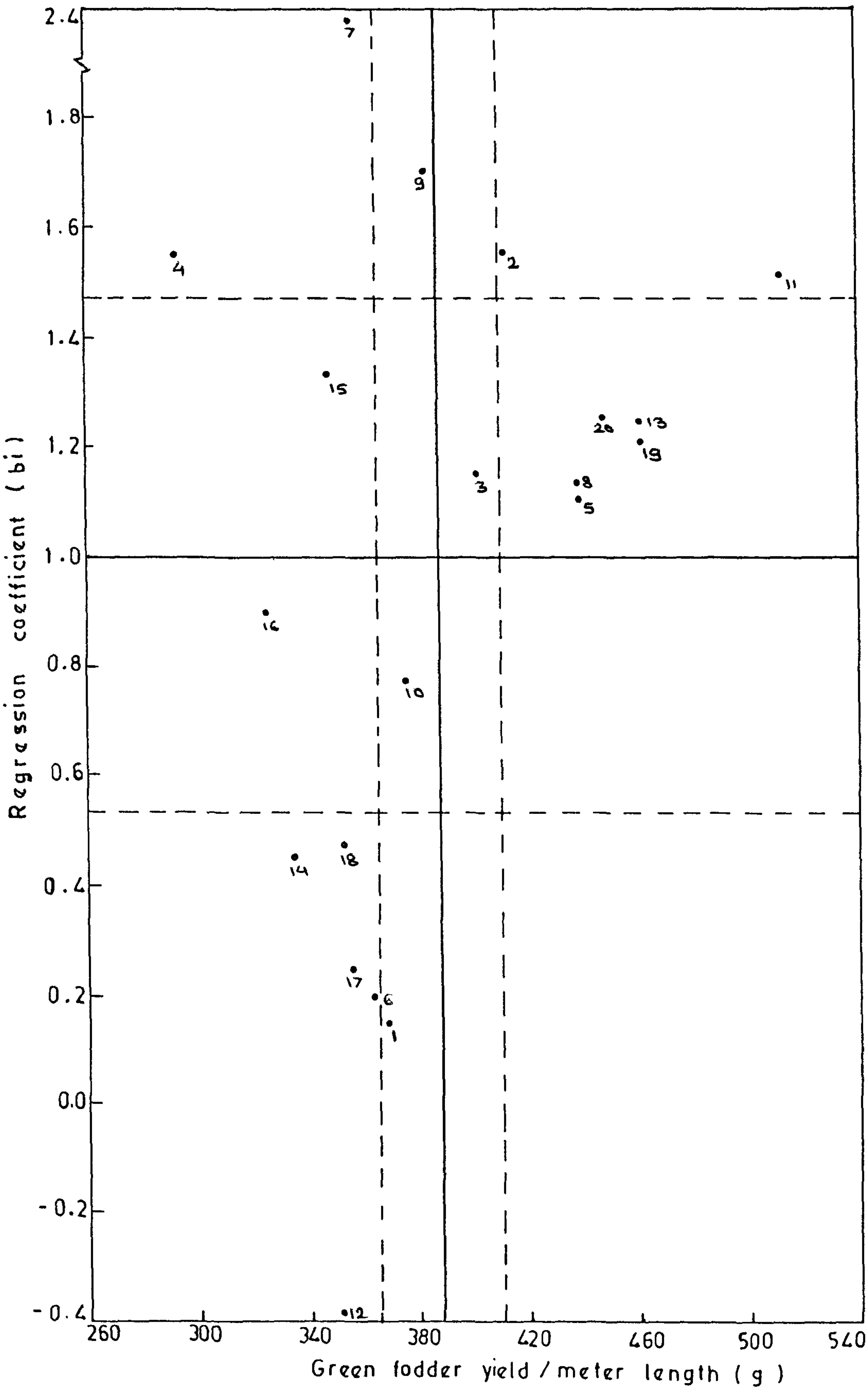


Fig. 5 Relation of green fodder yield/plant and stability
(E1 environment)

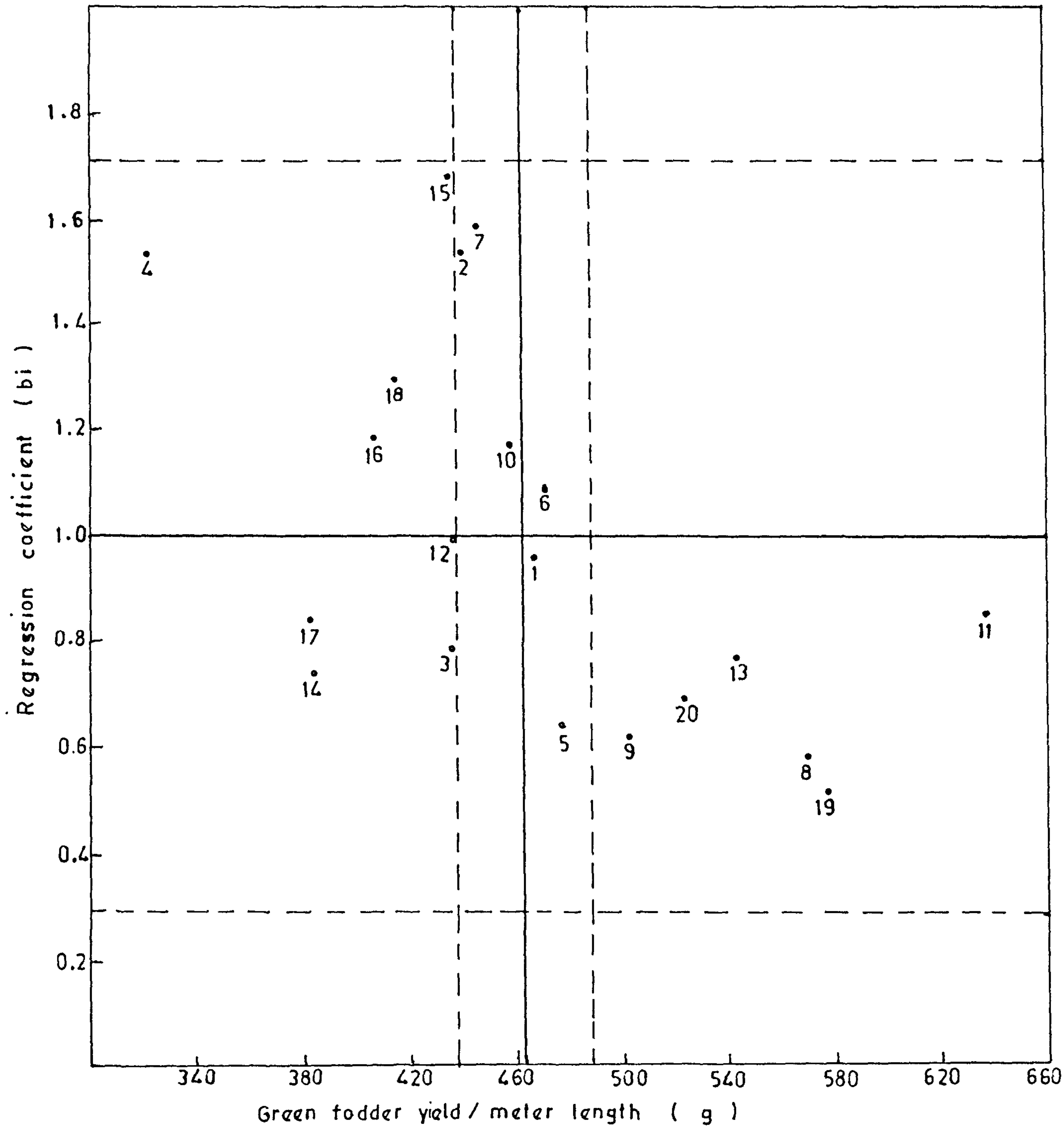


Fig. 6 Relation of green fodder yield/meter length and stability (E2 environment)

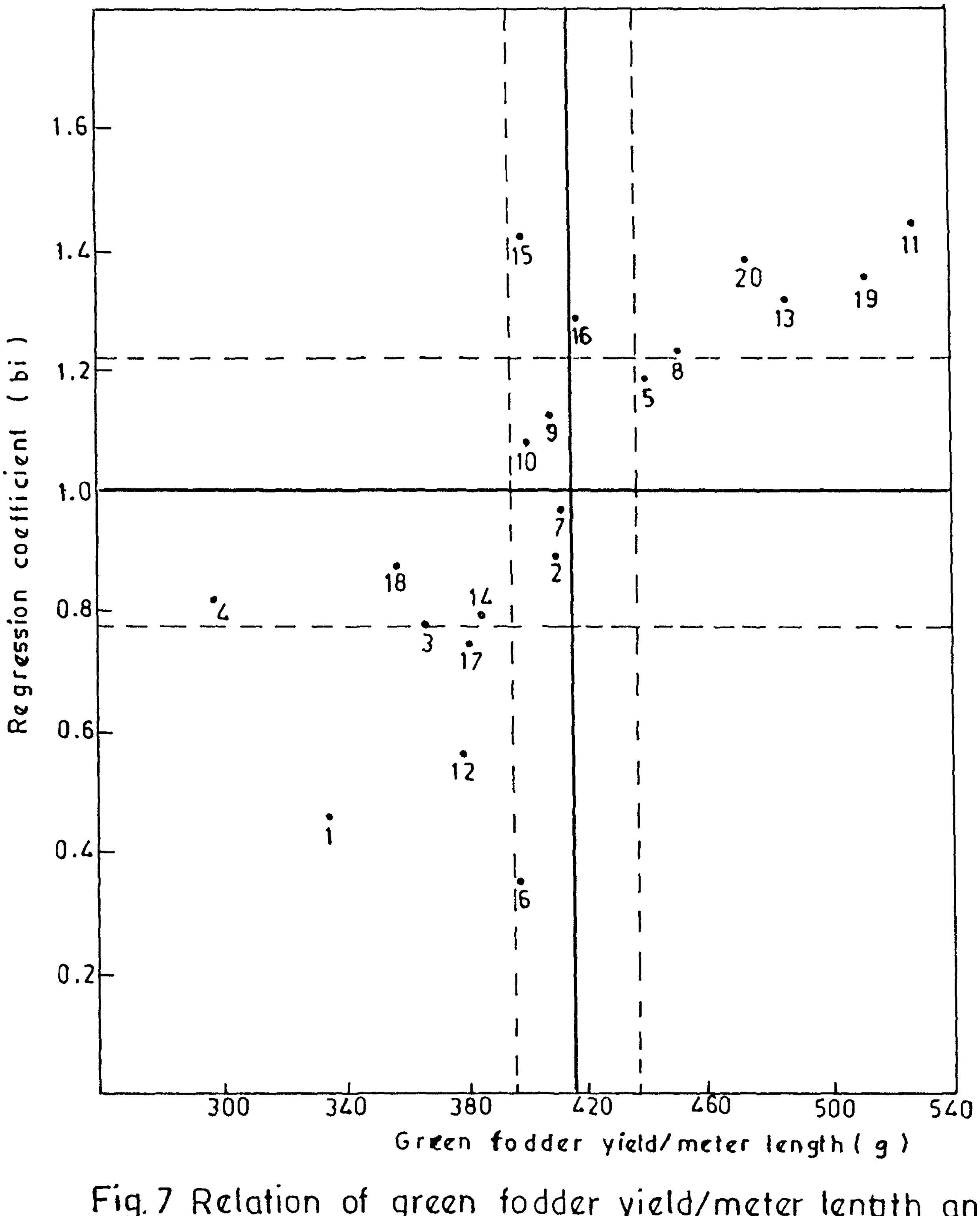


Fig. 7 Relation of green fodder yield/meter length and stability (E3 environment)

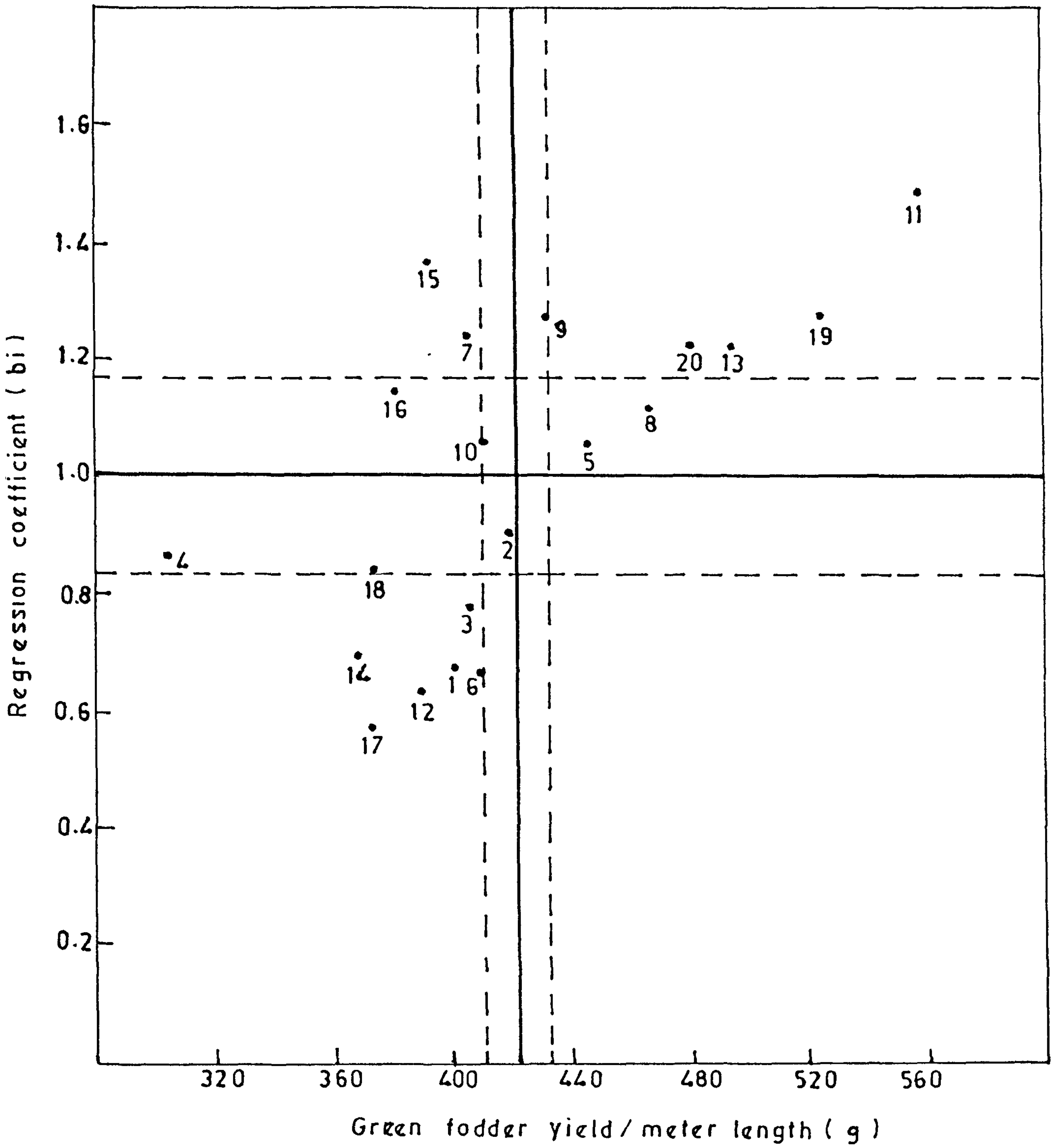


Fig. 8 Relation of green fodder yield/meter length and stability (Pooled)

E_3 environemnt had wider adaptability for L/S ratio. However, none of the genotypes exhibited wider adaptability over all the environments.

The genotype JHB-92-2 in E_1 environment and over all environment had wider adaptability for crude protein content. In addition to JHB-92-2 in E_1, BL-131, JB-92-1, JHB-93-2, JHB-93-3 and HFB-135 had wider adaptability. The genotypes, BL-122 and JHB-93-3 appeared with general adaptability in E_3 environment, while, the JHB-93-4 and Wardan were favourable to rich environment in E_3. None of the genotype was found to be stable in E_2 environment for crude protein content due to significant S^2di values.

Both linear and non linear components had significant contribution in the expression of L/S ratio and crude protein content.

The foregoing discussion revealed that the genotypes, JHB-93-3 (Plant height), JHB-92-2 (number of tillers per plant, crude protein yield), JHB-93-4, HFB-135, Wardan and Mescavi (number of tillers per plant) had general or wider adaptability over cuts per sowing times and fertilizer levels i.e. over all the environments.

In E_1 environment, the genotypes, BL-122 (plant height, green fodder yield per meter distance), BL-131 (plant height, crude protein content), JB-92-1 (plant height, dry fodder yield and crude protein content), JHB-92-2 (plant height, number of tillers per plant, protein content and green fodder yield per meter distance), JHB-93-3 (plant height, green and dry fodder yield per plant and crude protein content). JHB-146 (plant height, L/S ratio), HFB-135 (plant height, number of tillers per plant, crude protein content), Mescavi (plant height, number of tillers per plant, L/S ratio, dry fodder yield per plant and green fodder yield per metere distance), JHB-93-4 (number of tillers per plant, L/S ratio), RMBS-93-0-3, RMBS-93-3 and Wardan (number of tillers per plant), JHB-93-2 (L/S ratio, crude protein content), RMBS-93-0-1 (L/S ratio, green fodder yield per plant), RMBS-93-0-2 and RMBS-93-5 (L/S ratio) had wider adaptability.

In E_2 environment, the genotypes, JB-92-1 (plant height, number of tillers per plant, L/S ratio), JHB-92-2 (plant height, number of tillers per plant and per meter distance, green fodder yield per plant and per meter distance, dry fodder yield per plant), JHB-93-3 (plant height), JHB-93-4 (plant height, number of tillers per plant, dry fodder yield per plant), JHB-146 (plant height, L/S ratio, dry fodder yield per plant), HFB-135 (plant height, number of tillers per plant, green fodder yield per plant), Mescavi (plant height, number of tillers per plant and per meter distance, green fodder yield per plant and per meter distance). BL-122 (number of tillers per plant, L/S ratio), Wardan (number of tillers per plant, green and dry fodder yield per plant) BL-126 (number of tillers per meter distance, L/S ratio), BL-131, JHB-93-2 and RMBS-93-5-2 (number of tillers per meter distance) had general adaptability. While, the genotypes BL-126 (number of tillers per plant), Mescavi (L/S ratio), BL-122 and JHB-93-2 (green fodder yield) had below average stability and BL-130 (green fodder yield per plant) had above average stability in E_2 environment.

In E_3 environments, the genotypes exhibiting wider adaptability were JHB-93-2 (plant height, number of tillers per plant), JHB-93-3 (plant height, green fodder yield per plant, crude protein content), JHB-93-4 (plant height, number of tillers per plant and per meter length), Wardan (plant height, number of tillers per plant, geen fodder yield per meter distance), BL-131 (number of tillers per plant), JHB-92-2 (number of tillers per plant and per meter distance, green and dry fodder yield per plant), JHB-146 (number of tillers per plant), HFB-135 (number of tillers per plant and per meter distance green fodder yield per plant), Mescavi (number of tillers per plant and per meter distance, L/S ratio, green fodder yield per plant), RMBS-93-03 (number of tillers per meter distance, L/S ratio and green fodder yield per meter distance), RMBS-93-3 (L/S ratio) and BL-122 (crude protein content).

The genotypes, BL-126 (number of tillers per meter distance), JHB-93-4 (green and dry fodder yield per plant, crude protein content) and Wardan (dry fodder yield, crude protein content) were stuibatle for rich environment (below average stability) while, BL-102 (L/S ratio) was suitable for poor environment (above average stability) in E_3 environment.

Sowing of berseem in last week of December with 20 kg N + 80 kg P_2O_5 as a basal dose plus 10 kg N + 40 kg P_2O_5/ha after the first cut caused reduction in green as well as dry fodder yield. This decrease in forage yield was mainly due to decrease in plant height, number of tillers per meter distance, crude protein content and L/S ratio. The sowing in first week of December with 30 kg N + 120 kg P_2O_5/ha as a basal dose of fertilizer to berseem increased both, green and dry fodder yield.

Rana et al. (1992) reported that sowing of berseem crop on 25th October produced significantly higher green as well as dry fodder yield under the crop conditions responded upto 80 kg/ha application of phosphorus.

5.2 Correlation studies

The present investigation was also aimed to assess the magnitude and direction of the association between the different yield contributing characters and to detect the importance of these characters is determining the yield with the help of path coefficient analysis. The results obtained are discussed below.

Correlated characters are of interest for three reasons, first in connection with the genetic causes of correlation i.e. the pleiotropic action of genes and linkages, second, to know how the changes brought about by selection (it is important to know how the improvement of one character will cause simultaneous changes in other characters) and to know the role of natural selection in improving a trait (Falconer, 1960).

In the present investigation, correlation studies at genotypic and phenotypic levels were carried out in three environments for second cut to resolve the direction and magnitude of associations among the characters.

It was observed (Table 16 to 18) that the genotypic correlations were of greater magnitude than phenotypic correlations in most of the characters studied. This indicated that there is strong association between various characters studied and the genotypic expression of the correlation comparatively less influenced by the environment. The genotypic correlations are most realistic than phenotypic correlations because they give fairly reliable idea regarding inherent association between different traits, while phenotypic correlations are controlled by environmental fluctuations.

The present study revealed that green fodder yield per meter distance was positively and significantly correlated with plant height, number of tillers per plant and per meter distance, green fodder yield per plant, dry fodder yield per plant and crude protein content in all the three environments (E_1, E_2 and E_3). Similar relationship was reported earlier by Habib *et al*. (1971) and Shukla (1990) for plant height while Jatasra *et al*. (1980) for plant height, and dry matter yield per plant. L/S ratio exhibited non significant negative association with green forage yield in E_1 and E_2 and non significant positive association in E_3. Jatasra (1981) also reported no correlation between L/S ratio and green forage yield.

The plant height, number of tillers per plant, green fodder yield, dry fodder yield per plant and crude protein content had positively significant correlations among themselves in E_2 and E_3 environments. These are the important components of green forage yield. The selection for these characters individually or simultaneously, therefore, may be helpful in bringing out improvement in green fodder yield.

The linear relationship between yield and various components can sometime present a confusing picture as correlations are calculated often without taking into account the precise nature of inter relationship of the variables in question. Therefore, path coefficients analysis at a genothypic level offers much more realistic interpretation of the factors involved, the results of such analysis based on the data of the three environments for second cut, are discussed.

5.3 Path coefficient analysis

Genotypic path coefficient analysis as outlined by De wey and Lu (1959) was carried out to find out the direct and indirect effects of yield components on their correlation with green fodder yield per meter distance.

Plant height had positive direct effects on green forage yield per meter distance in E_1 and E_2 environments (Table 19 and 20) and negative in E_3 environments (Table 21). It's association with green fodder yield per meter distance however, was positively significant in all the three environments. It might be due to its direct effect and indirect effect via crude protein content in E_1 and E_2 environments. Though its direct effect on green forage yield per meter distance in E_3 environment was negative, but its association with green fodder yield was positively significantly it might be due its indirect effects via, number of tillers per plant and crude protein content.

Number of tillers per plant had negative direct effect in E_1 and E_2 environments, whereas, it had high positive direct effect on green forage yield per meter distance in E_3. The highly significant correlation of this trait with green fodder yield per meter distance was mainly due to its indirect effects via number of tillers per meter distance, crude protein content, green fodder yield per plant and plant height in E_1 and E_2 environments and through crude protein content, dry matter yield per plant, number of tillers per meter distance and L/S ratio in E_3 environment.

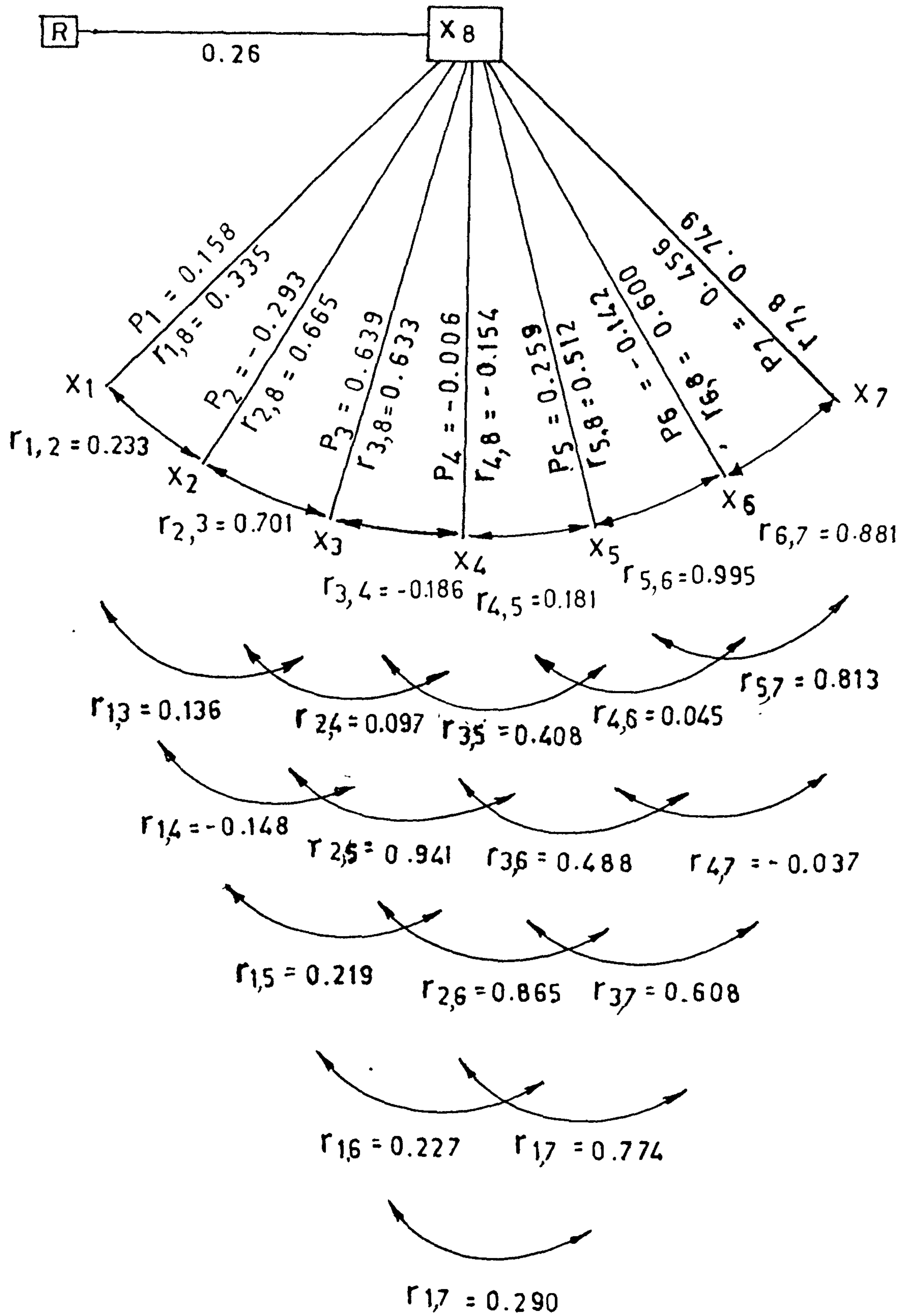


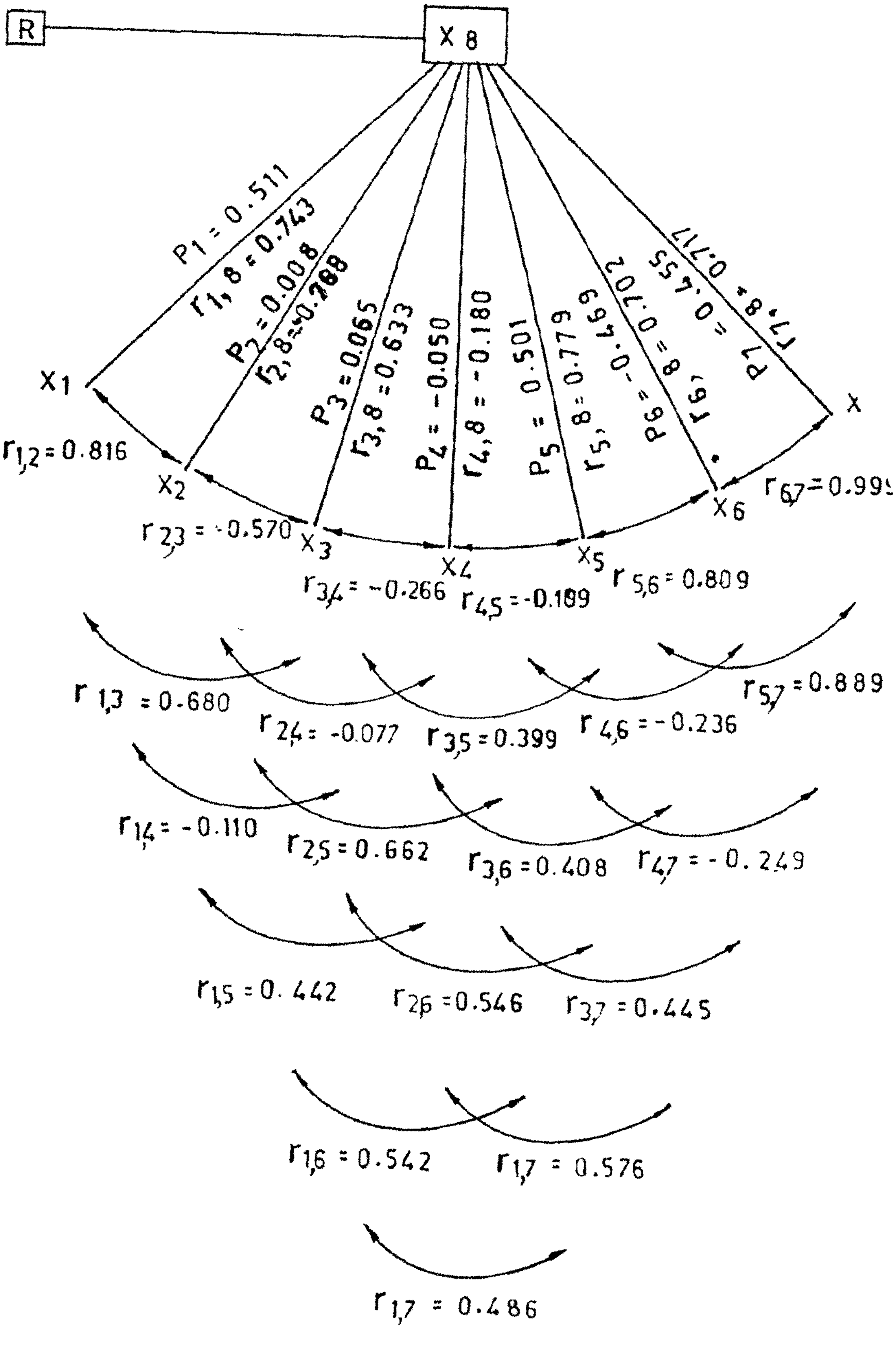
Fig. 9 Genotypic path diagram of E1- environment.

In E_3 environment, its association with yield was mainly due to its high direct effect.

Positive direct effects of plant height and number of tillers per plant on green forage yield also been reported by Jatasra et al. (1980).

Number of tillers per meter length had positive and high direct effects in E_1 and E_3 environments. Though low positive direct effect of this trait in E_2, it had strong positive correlation with green fodder yield which might be due to its indirect positive effects via plant height, green fodder yield per plant, crude protein content. The same trend was also found in E_1 environment. However in E_3 environment its indirect effects via number of tillers per plant, crude protein content and dry matter yield per plant was found to be positive.

In E_1 and E_2 environments, L/S ratio exhibited non significant negative correlation with green fodder yield per meter distance with low negative direct effects, whereas in E_3 environment, it was observed to be positively but non significantly correlated with green fodder yield with its medium positive direct effect. In E_1 environment its indirect effect via green fodder yield per plant was only positive, while its indirect effects via dry fodder yield per plant, number of tillers per plant (E_2) and via dry fodder yield per plant and crude protein content (E_3) were positive and via remaining traits the same were negative.



10 Genotypic path diagram of E2-environ-

The character green fodder yield per plant had medium to high positive direct effects in E_1 and E_2 environments, respectively, while it was negative in E_3 environment. The significantly high correlation of this triat in all the three environments with green fodder yield per meter distance was mainly due to its direct effect and indirect positive effects via crude protein content, number of tillers per meter and plant height in E_1 and E_2 environments while in E_3 environment, it was due to its indirect positive effects via all the characters except plant height.

Dry fodder yield per plant had negative direct effect on green fodder yield both in E_1 and E_2 environments. Whereas, its direct effect in E_3 was positive and medium in magnitude. However, it had strong positive association with green fodder yield per meter distance in all the three environments which resulted from highly indirect effects via crude protein content, tillers per meter distance, plant height in both E_1 and E_2 and also green fodder yield per plant in E_2 only. Its indirect effects in E_3 via crude protein content, number of tillers per plant were of high magnitude resulting in to highly significant correlation with green fodder yield per meter distance.

The crude protein content had high positive direct effect on green fodder yield in all the three environments. Its genotypic correlation with green fodder yield per meter

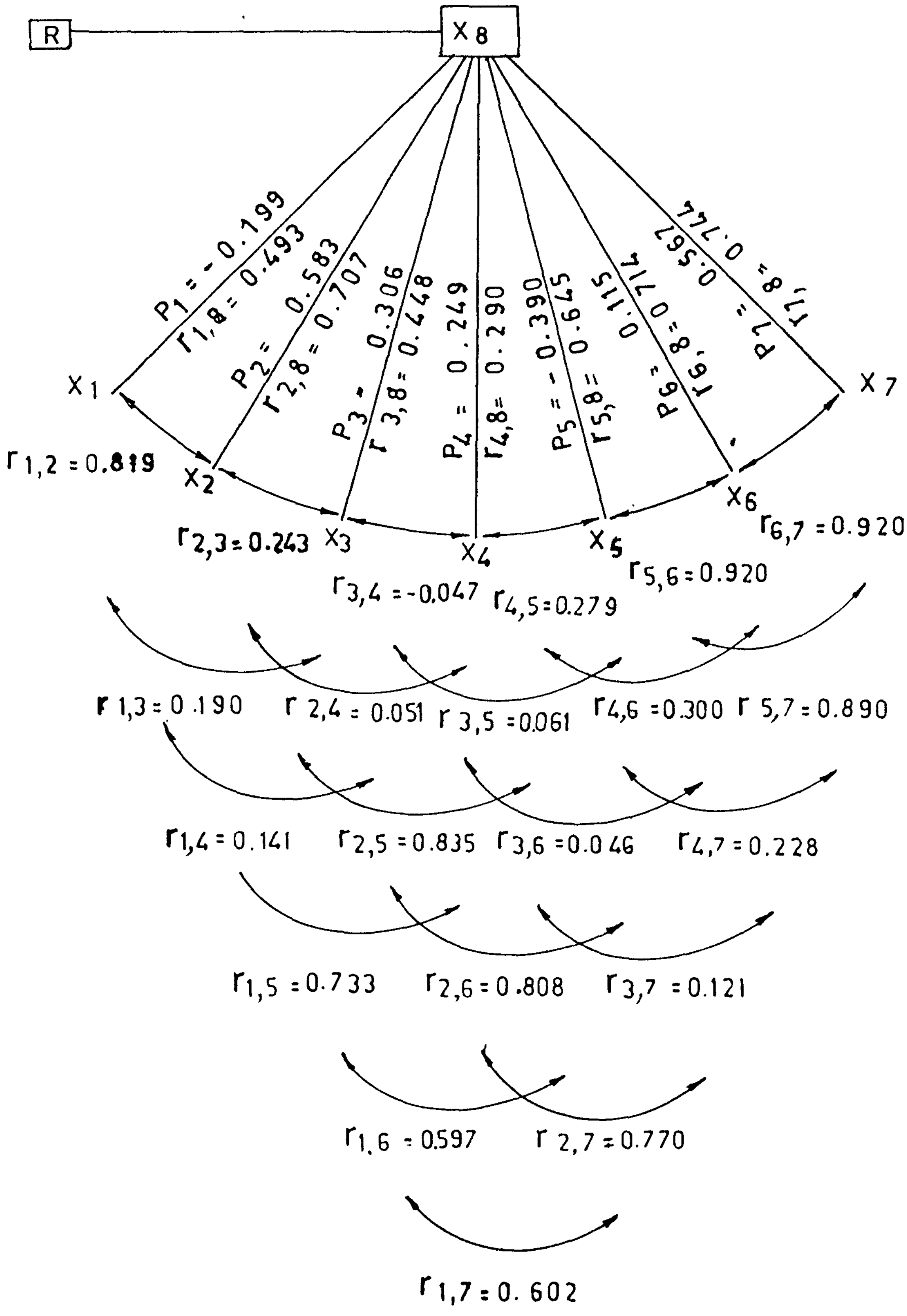


Fig.11 Genotypic path diagram of E3 environment

distance was also positive and highly significant which suggested that direct selection of this character will improve the green fodder yield.

In general, the magnitude of indirect effects of green fodder yield was substantial only through crude protein content, green forage yield, plant height and number of tillers per meter length.

From both, correlation and path analysis, it can be concluded that, plant height, crude protein content, number of tillers per plant or per meter distance and green fodder yield per plant are the important components of green fodder yield per meter distance and due importance be given for these traits during selection.

In all the three environments, residual effects were low (0.26, 0.19 and 0.23, respectively) indicating that almost all the yield contributing components have been considered in path analysis.

Table 22 : Nature of stability of genotypes under different environments

Sr. No.	Character	Nature of stability											
		Below average statility				Wider (general) stability)				Above average stability			
		E_1	E_2	E_3	Nine Env.	E_1	E_2	E_3	Nine Env.	E_1	E_2	E_3	Nine Env.
1.	Plant height	---	---	---	---	BL-122 BL-131 JB-92-1 JHB-92-2 JHB-93-3 JHB-146 HFB-135 Mescavi	JB-92-1 JHB-92-2 JHB-93-3 JHB-93-4 JHB-146 HFB-135 Mescavi	JHB-93-2 JHB-93-3 JHB-93-4 Wardan	JHB-93-3	---	---	---	---
2.	No.of tillers per plant	---	BL-126	---	---	JHB-92-2 JHB-93-4 HFB-135 RMBS-93-0-3 RMBS-93-3 Wardan Mescavi	BL-122 JB-92-1 JHB-92-2 JHB-93-4 HFB-135 Wardan Mescavi	BL-131 JHB-92-2 JHB-93-2 JHB-93-4 JHB-146 HFB-135 Wardan Mescavi	JHB-92-2 JHB-93-4 HFB-135 Wardan	---	---	---	---
3.	No. of tillers per meter	---	---	BL-126	---	---	BL-126 BL-131 JHB-92-2 JHB-93-2 RMBS-93-5-2 Mescavi	JHB-92-2 JHB-93-4 HFB-135 RMBS-93-0-3 Wardan Mescavi	---	---	---	---	---
4.	Leaf/stem ratio	---	Mescavi	---	---	JHB-93-2 JHB-93-4 JHB-146 RMBS-93-01 RMBS-93-0-2 RMBS-93-5-2 Mescavi	BL-122 BL-126 JB-92-1 JHB-146	RMBS-93-03 RMBS-93-3 Mescavi	---	---	---	BL-102	---

Table 22 contd...

Sr. No.	Character	Nature of stability											
		Below average statility				Wider (general) stability)				Above average stability			
		E_1	E_2	E_3	Nine Env.	E_1	E_2	E_3	Nine Env.	E_1	E_2	E_3	Nine Env.
5.	Green fodder yield	---	BL-122 JHB-93-2	JHB-93-4	---	JHB-93-3 RMBS-93-0-1	JHB-92-2 HFB-135 Wardan Mescavi	JHB-92-2 JHB-93-3 HFB-135 Mescavi	---	---	BL-130	---	---
6.	Dry matter yield/plant	---	---	JHB-93-4 Wardan	---	JB-92-1 JHB-93-3 Mescavi	JHB-92-2 JHB-93-4 JHB-146 Wardan	JHB-92-2	---	---	---	---	---
7.	Crude protein yield	---	---	JHB-93-4 Wardan	---	BL-131 JB-92-1 JHB-92-2 JHB-93-2 JHB-93-3 HFB-135	---	BL-122 JHB-93-3	JHB-92-2	---	---	---	---
8.	Green fodder yield/meter distance	---	---	---	---	BL-122 JHB-92-2 HFB-135 Mescavi	JHB-92-2 Mescavi	RMBS-93-03 Wardan	---	---	---	---	---

6. SUMMARY AND CONCLUSIONS

Twenty promising berseem genotypes were evaluated in the present investigation on 'Adaptability and path analysis' to know the nature of their stability and inter se relationship and direct-indirect effects of the components on green forage yield per meter distance.

The observations were recorded on plant height, number of tillers per plant, number of tillers per meter distance, L/S ratio, green fodder yield per plant, dry fodder yield per plant, crude protein content and green fodder yield per meter distance.

6.1 Summary

6.1.1 Adaptability studies

Stability analysis as per the model of Eberharl and Russell (1966) showed presence of G x E interaction for all the characters in E_1, E_2 and E_3 predictable environment as well as over all the environments. Environmental variances were significant for all the characters except L/S ratio in E_1 and E_2 environments.

Linear component of genotype x environment interaction was significant for plant height in E_1, E_2 and over all environment, number of tillers per plant only in E_1, number of tillers per meter distance in E_2, E_3 and over all environment, green fodder yield per plant in E_1, E_2 and over all environments, dry fodder yield per plant both in a set of three and nine environments and for green fodder yield per meter distance in E_1, E_3 and over nine environments. Environment (linear) variances were also significant for all the characters except L/S ratio in E_1 and E_2 environments.

Based on environmental indices (I_j the first cut of berseem in general as the most favourable for all the characters except green fodder yield per plant in E_2 and plant height in E_3 environment. However, third cut was favourable for plant height, number of tillers per meter distance in E_1 and E_3, green fodder yield per plant and per meter distance in all predictable environments.

6.1.2 Correlation and path analysis

The genotypic and phenotypic correlation coefficients were worked out for the data recorded on second cut in three predictable environments. However, the path analysis was done only at genotypic level.

6.2 Conclusions

6.1.1 Adaptability

1. Differential responses of the genotypes for all the characters studied indicated the necessity to test the adaptability of genotypes to maximise the forage productivity.
2. Significant pooled deviation (non linear component of G x E) for all the characters except number of tillers per plant in E_1 environment revealed difficulties in

predicting the performance of the genotypes over seasons.

3. Based on the estimates of environmental indices (I_j) the first cut approved as the most favourable for yield and its components.

4. The genotypes viz., JHB-93-3 (plant height), JHB-92-2 (number of tillers per plant, crude protein yield), JHB-93-4, HFB-135, Wardan and Mescavi (number of tillers per plant) were found promising and had stable performance over all the environments for the above mentioned characters.

5. In E_1 environment (sowing in first week of December with 20 kg N + 80 kg P_2O_5/ha), the genotypes viz., BL-122 (plant height, green fodder yield per meter distance), BL-131 (plant height, crude protein content), JB-92-1 (plant height, dry matter yield, crude protein content), JHB-92-2 (plant height, number of tillers per plant, crude protein content, green fodder yield per meter distance), JHB-93-3 (plant height, green fodder yield per plant, dry matter yield, crude protein content), JHB-146 (plant height, L/S ratio), HFB-135 (plant height, number of tillers per plant, crude protein content, green fodder yield per meter distance), Mescavi (plant height, number of tillers per plant, L/S ratio, dry matter yield, green fodder yield per meter distance), JHB-93-4 (number of tillers per plant, L/S ratio), RMBS-93-0-3, RMBS-93-3 and Vardan (number of

tillers per plant), JHB-93-2 (L/S ratio, crude protein contnet), RMBS-93-0-1 (L/S ratio, green fodder yield), RMBS-93-0-2 and RMBS-93-5-2 (L/S ratio) had general (wider) adaptability.

6. The genotypes viz., JHB-93-4 (plant height, number of tillers per plant, dry fodder yield), JB-92-1 (plant height, tillers per plant , L/S ratio), JHB-92-2 (plant height, number of tillers per plant and per meter distance, green fodder yield, dry fodder yield), JHB-93-3 (plant height), JHB-146 (plant height, L/S ratio, dry fodder yield), HFB-135 (plant height, number of tillers per plant, green fodder yield per plant), Mescavi (plant height, number of tillers per plant and per meter length, green forage yield per plant and per meter distance), Wardan (number of tillers per plant, dry and green fodder yield per plant), BL-122 (number of tillers per plant, L/S ratio), BL-126 (number of tillers per meter distance, L/S ratio), BL-131, JHB-93-2 and RMBS-93-5-2 (number of tillers per meter distance) in E_2 environment had wider adaptability.

7. In E_3 environment, the genotypes viz., JHB-93-4 (plant height, number of tillers per plant and per meter distance), JHB-93-2 (plant height, number of tillers per plant), Wardan (plant height, number of tillers per plant and per meter distance, green fodder yield per meter distance), JHB-93-3 (plant height, green fodder yield per plant, crude protein content), BL-131 (number of tillers per plant), JHB-92-2 (number of tillers per

plant and per meter distance, green fodder yield per plant, dry matter yield), HFB-135 (number of tillers per plant and per meter distance, green fodder yield per plant), Mescavi (number of tillers per plant and per meter distance, L/S ratio, green fodder yield), RMBS-93-0-3 (number of tillers per meter distance, L/S ratio and green fodder yield per meter distance), RMBS-93-3 (L/S ratio) and BL-122 (protein content) had wider adaptability for the characters indicated in the parentheses.

8. Over all, the genotypes viz., JHB-92-2, HFB-135 and Mescavi in all the three predictable and in addition to this JHB-93-3 in E_1 and Wardan in E_3 environment were found to be stable for most of the characters such as plant height, number of tillers, green and dry fodder yield and crude protein content.

9. The genotypes viz., BL-126 (tillers per plant), Mescavi (L/S ratio), BL-122 and JHB-93-2 (green fodder yield) in E_2 environments whereas, in E_3 environment, BL-126 (tillers per meter distance), JHB-93-4 (green fodder yield per plant, dry fodder yield, crude protein content) and Wardan (dry fodder yield, crude protein content) showed below average stability i.e. suitability to favourable contitions.

10. The genotype BL-130 had above average stability i.e. suitability to poor environment in E_2 environment for green forage yield per plant, while BL-102 exhibited above average stability for L/S ratio in E_3 environment.

6.2.2 Correlation and path analysis

1. Correlation studies indicated the importance of plant height, number of tillers per plant and per meter distance, crude protein content, green and dry fodder yield per plant in the selection criterion.
2. Based on direct and indirect effects under various environments, the yield components such as plant height, crude protein content, number of tillers per plant and green fodder yield per plant appeared as the important traits in the selection aimed at improvement of fodder yield of berseem.

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*** Originals not seen.**

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8. VITA

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