“Variability and Correlation Analysis in Fenugreek (*Trigonella foenum-graecum* L.)’’

THESIS

Submitted to the

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

Gwalior

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

In

HORTICULTURE

(Plantation, Spice, Medicinal and Aromatic Crops)

By

MAHENDRA GURJAR

Department of Plantation, Spice, Medicinal and Aromatic Crops

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior

College of Horticulture, Mandsaur (M.P.)

2013

CERTIFICATE - I

This is to certify that thesis entitled "Variability and correlation analysis in fenugreek (*Trigonella foenum-graecum* L.)" submitted in the partial fulfillment of the requirements of the degree of **MASTER OF SCIENCE IN HORTICULTURE (PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.), is a record of the bonafide research work carried out by **Mr. Mahendra Gurjar,** ID. No. Horti./MAND/494/2007 under my guidance and supervision. The Student's Advisory Committee and the Director of Instruction have approved the subject of thesis.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published / published part has been fully acknowledged. All the assistance and help received during the course of the investigation has been acknowledged by him.

(Dr. Pushpendra Pratap Singh)

CHAIRMAN OF THE ADVISORY COMMITTEE

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman (Dr. P.P. Singh) ………………….

Member (Dr. I.S. Naruka) ………………….

Member (Dr. S.N. Mishra) ………………….

Member (Dr. G.P.S. Rathore) ………………….

CERTIFICATE - II

This is to certify that the thesis entitled "Variability and correlation analysis in fenugreek (*Trigonella foenum-graecum* L.)" submitted by **Mr. Mahendra Gurjar**, ID. NO. **Horti./MAND/494/2007,** to the **Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior** in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN HORTICULTURE** in the department of **PLANTATION, SPICE, MEDICINAL AND AROMATIC CROPS** has after evaluation been approved by the external examiner and by the Student's Advisory Committee after an oral examination on the same.

Place: Mandsaur
Date:

(Dr. Pushpendra Pratap Singh)
CHAIRMAN ADVISORY COMMITTEE

Members of the Advisory Committee

(Dr. I.S. Naruka) ………………….

(Dr. S.N. Mishra) ………………….

(Dr. G.P.S. Rathore) ………………….

Forwarded to the Dean, College of Horticulture, Mandsaur for further necessary action.

HEAD OF SECTION

Endt. No.COH/Acd/PG/Thesis/12-13……... **Mandsaur, Dated………….**

Forwarded to the Director Instrutions, RVSKVV, Gwalior (M.P.) for further necessary action.

DEAN

Forwarded to the Registrar, RVSKVV, Gwalior (M.P.), for further necessary action.

DIRECTOR OF INSTRUCTION

ACKNOWLEDGEMENT

Glory to God the Almighty who has not failed me. I take it to be my proud privilege to avail this opportunity to express my sincere and deep sense of gratitude to my learned advisor Dr. P.P. Singh, Asst. prof., Department of Plantation and Spice Crops, for his stimulating guidance, constructive suggestions, keen and sustained interest and incessant encouragement bestowed during the entire period of investigation, as well as critically going through the manuscript.

I am gratified to record sincere thanks to the members of the advisory committee; Dr. I.S. Naruka, Assistant Professor & Head of the Department of Plantation and Spice Crops, Dr. S.N. Mishra, Seniors Scientists Department of Soil Science and plant biochemistry and Dr. G.P.S. Rathore, Asst. Prof., Department of Agricultural Statistics for their generous gestures and valuable suggestions in planning and execution of this study.

I am privileged to express sincere and deep sense of gratitude to Dr. A.K. Singh, Hon’ble Vice Chancellor, R.V.S.K.V.V., Gwalior, Dr. R. L. Rajput, Director of Instruction and Dr. B.S. Baghel, Dean, Faculty of Agriculture R.V.S.K.V.V., Gwalior. With deepest sense of humility and gratefulness, I feel myself duly bound to express my heartfelt and sincere thanks to Dr. H. Patidar, Dean College of Horticulture, Mandsaur for his due attention and encouragement during the study period and also for providing me the necessary facilities during the course of study.

Words can hardly register the sincere and heartfelt feeling, which I have for Dr. R.P.S. Shaktawat Dr. S.P.S. Somvanshi, my batch met Neeraj Silawat, Vijay Rathore (bhai), Dinesh Meena (D.K), Amit Yadav, Lokesh Patidar (Loku), Manish Beohar(mannu dada), Dushyant Nagar (dust), Jitendra Patidar (jitu), Sanjeev Raghuvanshi (mama), J.P. meena, Rahul Patidar (chacha), Hariom Patidar, Badri, Vipin, Radha, Lesha, my seniors Ajay chuodhary, Manoj malaw, Jitendra Bagari, P.S. Lodhi. Ganesh Patel, Sanjeet Bagari, P.R.Bagari, K.P. Jat, Santosh sarate (biotec) and Ranjana mandloi and juniors Umesh Kadbe, Gajendra Sekhawat, Palak Jain(Single haddi), Rakesh kalam(painter), Rajesh Meena(raju baba), V.Prabhakar(Hydradadi), Dinesh Uikey(Baba), Manish Patidar (mhenti), Tufan singh

(RAEO), Subodh Thakre(dhila), M.P. Baghal, Raja, Amit Patel, Ravi Jaswal, H.B. Mehara (Milk mean), and for their kind, co-operation and help as when needed.

Place – Mandsaur

Date - **(Mahendra Gurjar)**

LIST OF CONTENTS

List of Tables

List of Figures

List of Appendices

List of Photo Plates

ABBREVIATIONS USE IN TEXT

/	:	Per
@	:	At the rate of
%	:	Percentage
ANOVA	:	Analysis of variance
C.D.	:	Critical difference
cm	:	Centimeter
^{0}C	:	Degree Celsius
Cv.	:	Cultivar
Cv	:	Coefficient of variation
D.F.	:	Degree of freedom
DAS	:	Days after sowing
et al.	:	and others
Fig.	:	Figure
&	:	and
g	:	Gram
GA	:	Genetic advance
Gcv	:	Genotypic coefficient of variation
ha.	:	Hectare
hr	:	Hour
i.e.	:	That is
R.V.S.K.V.V.	:	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
K	:	Potassium
Kg	:	Kilogram
Kg ha^{-1}	:	Kilogram per hectare
Max.	:	Maximum
Min.	:	Minimum
Mg.	:	Milligram
MOP	:	Murate of potash
M.S.S.	:	Mean sum square
MT	:	Metric Tonne
M^2	:	Meter square
N	:	Nitrogen

No.	:	Number
NS	:	Non significant
P_2O_5	:	Phosphorus
Pcv	:	Phenotypic coefficient of variation
Ppm	:	Part per million
R.H.	:	Relative humidity
Rs.	:	Rupees
r	:	Coefficient of correlation
S	:	Sulphur
SEm	:	Standard error of mean
*	:	Significant
q/ha	:	Quintal per hectare
Viz.	:	(Videlicet) Namely
Wt.	:	Weight

1. INTRODUCTION

Fenugreek (*Trigonella foenum graecum* L.), 2n=16 popularly known as "*Methi*" is an important seed spice crop largely grown in India during *Rabi* season. It is an annual spice crop both leaves and seeds are extensively used for medicinal purposes. It belongs to family fabaceae.

Fenugreek seeds are used as condiments and flavouring food preparations. They are aromatic, carminative, tonic and galactagogue. Externally they are used in poultices for boils, abscesses, ulcers and internally as emollient for inflammation of intestinal tract. The seeds contain important steroid 'diosgenin' which is used in preparation of contraceptives.

The genus *Trigonella* has two species *viz*., *T. foenum-graecum* and *T. corniculata. Trigonella foenum-graecum* plants are semi-erect, tall, moderately branched with bold, typically yellow grains. Plants of *Trigonella corniculata* are bushy green, the flowers are bright orange yellow medium sized and pods are small and sickle shaped.

Fenugreek is considered to have originated in South Eastern Europe and West Asia (Gangopadhyay *et al.* 2009). In India it is mainly cultivated in the states of Rajasthan, Gujrat, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Himachal Pradesh and Haryana. In India, during 2012-2013, fenugreek was cultivated on 94.00 thousand hectare with an annual production of 116.00 thousand MT (Anonymous, 2012). Rajasthan and Gujrat are the major fenugreek producing states followed by Madhya Pradesh in which Malwa plateau contributes a major share. In Madhya Pradesh, fenugreek-growing districts are Jabalpur, Chhatarpur, Indore, Mandsaur, Neemuch, Ratlam and Shajapur.

The maximization of seed yield of fenugreek is the major objectives for its improvement. Very little effort has been made in collection, maintenance and utilization of different genotypes for the improvement of this crop. There is need to assess and improve the existing genotypes and introduce cultivars for seed purpose.

Study of variability is a prerequisite for improvement of yield in any crop. The performance of locally available cultivars of fenugreek is poor in the Malwa region of Madhya Pradesh. Hence there is an urgent need for genetic improvement to develop high yielding cultivars suitable for such situations.

The concept of path coefficient analysis was originally developed by Wright in 1921, but the technique was first used for plant selection by Dewey and Lu in 1959. Path analysis is simply standardized partial regression coefficient, which splits the correlation coefficients into the measures of direct and indirect effects of a set of independent variables on the dependent variable. Path analysis is carried out using the estimates of correlation coefficients.

With the above mentioned facts the present investigation entitled "Variability and Correlation Analysis in Fenugreek (*Trigonella foenum-graecum* L.)'' was carried out at College of Horticulture, Mandsaur (M.P.) during the *rabi* season of 2012-2013 with the following objectives:

1. To find out the variability present in germplasm of fenugreek.
2. Evaluation of genotypic and phenotypic characters in fenugreek.
3. To find out the yield and yield component characters in fenugreek through correlation.

2. REVIEW OF LITERATURE

The present investigation entitled "Variability and Correlation Analysis in Fenugreek (*Trigonella foenum-graecum* L.)'' has been undertaken at College of Horticulture, Mandsaur during the year 2012-13.The relevant literature available in this regard has been reviewed and presented in this chapter.

2.1 Variability

Crop improvement in any plant species depends upon exploiting the existing genetic variability in the crop. Assignment of genetic variability is usually made through the estimates of genetic parameters of variation such as range, mean and phenotypic variances and their coefficients of the characters under consideration. It has been observed that genotypes within the species exhibited variation in different traits and components of yield. The genetic variability is important in all plant breeding programme greater the genetic variability, wider will be the scope for selection in the crop-breeding programme. The literature available on these aspects in fenugreek has been reviewed and presented as under.

Pant *et al*. (1984) reported high positive association between pod length, beak length and seeds per pod, while high negative correlation was recorded for pod length with pods per plant, while beak length showed positive correlation with seeds per pod, pod per plant, whereas pods per plant had a highly negative association with seeds per pod.

Kohli *et al.* (1988) studied the fifteen cultivars of fenugreek with regard to characters, such as green yield, days to flowering, plant height, number of leaves, leaf area, seed yield, number of pods, pod length, thousand seed weight, total dry matter and number of shoots. Variability for all these characters except thousand seed weight was highly significant.

Sharma *et al*. (1990) studied the in one hundred genotypes of fenugreek (*Trigonella foenum-graecum* L.) and reveals that significant variability for 11 characters except number of grains per pod and 1000 grain weight.

Singh *et al.* (1993) in the 32 diverse genotypes of fenugreek, representing exotic and Indian origin, the association pattern among the seed yield attributes was investigated under two dates of sowing. The correlation and path coefficient study indicated that for obtaining the higher seed yield in fenugreek the selection should be based on a plant type having more height, more tertiary branches, more pod length, more seed per pod, and more 100-seed weight.

Hariharan and Vijaya Kumar (1997) studied on the genetic variability in fenugreek was under taken in sixty genotypes with 18 component characters in which yield of seed per plant and seed protein content revealed significant difference among the genotypes.

Chandra *et al*. (2000) reported on 72 lines of fenugreek has shown existence of high variability for seed yield, number of pods per plant and protein content while low variability was recorded for days to flowering and number of grains per pod. High broad sense heritability and genetic advance estimates were obtained for protein content and number of pods per plant.

Saha and Kole (2001) studied for genetic variability on fifteen genotypes of fenugreek was analyzed for variance revealed highly significant differences among genotypes for all the character studied.

Dash and Kole (2001) studied for twelve quantitative characters in fenugreek found wide range of variability among them. The estimate of broad sense heritability was high for pods per plant, test weight, grains per pod, pod length and days to flowering.

Verma and Korla (2003) reported on the performance of 39 accessions of fenugreek (*Trigonella foenum-graecum* L.), were evaluated under mid-hill conditions of Himachal Pradesh. The coefficient of variation was high for the economic and biological yield of the crop. Heritability in the broad sense was high for plant height and moderate for 1000 seed weight, number of branches per plant, total seedling length and germination percentage.

Kumar and Choudhary (2003) reported on the different parameters were estimated to assess the magnitude of genetic variability in 12 diverse genotypes of fenugreek. The analysis of variance indicated the prevalence of sufficient genetic variance among the genotypes for all the 18 characters studied. Genotypic coefficient of variation, estimates of variability and genetic gain were moderate to high for number of pods per plant, 1000 seed weight, pod length and number of seeds per pod which indicated the selection would be very effective for yield component characters.

Banerjee and Kole (2004) studied on different type 22 genotypes of fenugreek and observed that the phenotypic and genotypic coefficient of variability were high for stem weight moderate for plant height, branches per plant, days to flowering, duration of flowering, shelling percent and test weight and low for pod length.

Datta and Chatterjee (2004) studied on eight fenugreek genotyped namely, RMt-1, Rajendra Kranti, J. Fenu-195, HM-350, Pusa Early Bunching, RMt-143 and UM-303 were evaluated against local cultivars for growth, yield. All characters except primary branches perplant showed significant variation.

Datta *et al*. (2005) found that the magnitude of genotypic and phenotypic coefficient of variation ranged from 3.07 to 19.20 and 5.55 to 20.42, respectively. High genotypic coefficient of variation ranged from 3.07 to 19.20 and 5.55 to 20.42, respectively. So, the direct selection may be carried out on the basis of genotypic and phenotypic coefficient of variation.

Balai *et al.* (2006) studied on 36 genotypes including checks of fenugreek (*Trigonella foenum-graecum* L.) has showed significant variability for all the ten traits. High estimates of PCV along with GCV as well as heritability and GA were observed for fat content, protein content and number of pods per plant. High heritability along with moderate GA was recorded for plant height and seed yield per plant.

Sarada *et al*. (2008) investigated on twelve genotypes of fenugreek to estimate the correlation coefficients for yield and yield components. The phenotypic and genotypic correlation studied showed that association of seed yield with plant height, number of pods per plant, pod length, and number of seeds per pod was appreciable, indicating the importance of these traits as component

Sarada *et al. (*2008) investigation was carried out with fenugreek genotypes obtained from different coordinating centers of AICRP on Spices. Pods per plant (36.5 and 34.61), number of seeds per pod (22.86 and 21.20) and seed yield (22.09 and 17.21) recorded highest coefficients of variation (both phenotypic and genotypic), while it was low for pod length (11.43 and 7.32). Heritability estimates were high for plant height (83.10), pods per plant (89.90) and seeds per pod (86.00). Seed yield (60.70) and branches per plant showed moderate estimates of heritability. The characters viz. plant height, pods per plant, seeds per pod and seed yield which recorded high heritability also showed high genetic advance indicating operation of additive gene action in the inheritance of these traits. These studies indicated that selection may be Worthwhile in fenugreek for number of pods per plant, seeds per pod besides plant height for achieving higher yields.

Gangopadhyay *et al*. (2009) conducted an experiment during winter (rabi) season of 2004 and 2005 to assess the correlation, path-coefficient, and genetic variability in 40 morphologically diverse accessions of fenugreek (*Trigonella foenum-graecum* L.). Results showed Plant height, primary branches, days to 50% flowering, pods per plant, grains per pod, days to maturity, 1000-seed weight and seed yield per plant showed significant differences and wide variations in both the years.

Singh *et al.* (2009) sixty diverse genotypes of fenugreek germplasm (*Trigonella foenum-gracecum* Linn) were evaluated where phenotypic co-efficient of variation was greater than genotypic co-efficient of variation regarding yield per plot, yield (t/ha), 1000 grain weight, number of pods per plant, length of pod and number of grains per pod. Four character i.e., 1000 grain weight, length of pod, number of days to 50% flowering and number of grains per pod exhibited high heritability. Highest genetic advance was recorded with yield (t/ha) or yield per plot, number of grains per pod. It ranged from 0.02% to 16.36 % for all the character.

Prajapati *et al*. (2010) evaluated sixty four genotypes of fenugreek were evaluated for genetic variability, correlation and path coefficient analysis at Jagudan (Gujarat). Phenotypic and genotypic coefficients of variability were high for grain yield per plant, no. of pods per plant and no. of primary branches per plant. Moderate heritability estimates along with high genetic advance as percentage of mean were recorded for number of pods per plant.

Dashora *et al.* (2011) evaluated 48 genotypes of fenugreek and reported that highly significant differences between genotypes were recorded for all the character studied. High phenotypic and genotypic coefficient of variation coupled with high heritability and high genetic advance was observed for seed yield per plot, biological yield per plot, harvest index and pods per plant indicating the importance of additive gene effects for these traits. Biological yield per plot and harvest index exhibited positive and significant correlation with seed yield while days to 50% flowering exhibited negative and significant association with seed yield.

Meena *et al.* (2011) studied seventeen released varieties of fenugreek and reported the characters, plant height, no. of primary branches and yield per plant had high heritability and genetic advance suggesting that improvement for these characters could be brought about by direct selection. Pod length, pod width, pods per plant and 1000 seed weight exhibited high heritability with low genetic advance but these characters must be taken up in advance generation.

Fikreselassie *et al.* (2012) reported the mean squares of the accessions were highly significant for most of the characters, implying that a wide range of variability has been obtained for the traits studied. The GCV ranged from 1.65 to 68.95%, while the PCV from 3.30 to 158.06%. The estimated broad sense heritability ranged from 2.92 to 82.02%. The first four PC accounted for more than 88% of the total variation. The 144 germplasm materials were grouped into six clusters based on Mahalanobis' D2 statistic. It was asserted that geographic diversity should not necessarily be used as an index of genetic diversity and parental selection but should be based on systematic study of genetic diversity in a specific population.

Naik (2012) studied with 22 genotypes in field condition and high genotypic coefficient of variation for number of secondary branches, number of pods per plant and seed yield was observed in fenugreek (Banerjee and Kole,2004 and Datta *et al*., 2005). High heritability coupled with high genetic advance in per cent of mean were observed for number of pods per plant, number of branches per plant, number of seeds per pod and plant height. It is also reported that high heritability for pods per plant, pod length and seed yield, while low heritability was observed for seeds per pod and test weight. However, high genetic advance was recorded for pods per plant and seed yield and a low genetic advance was recorded for test weight, seeds per pod and branches per plant. Selection of these characters would be effective for obtaining high yielding genotype by additive gene effect.

2.2 Correlation coefficient

Dash and Kole (2000) studied in a population of 15 genotypes of fenugreek. Pods per plant, grains per pod, straw yield, biological yield and harvest index showed significantly positive correlations with grain yield per plant at both genotypic and phenotypic levels.

Saha and Kole (2001) reported the genotypic and phenotypic correlations in 15 genotypes of fenugreek for days to flowering, plant height, pods per plant, pod length, grains per pod, straw yield, biological yield and harvest index with grain yield per plant were significant and positive indicating the importance of these characters in seed yield improvement.

Kumar and Choudhary (2002) studied the correlation coefficients and heritability of 19 characters of 12 fenugreek cultivars. Data reveals that yield was positively and significantly correlated with plant height, pod length, number of seeds per pod, yield per plant and plot, length of tap roots and number of secondary roots.

Banerjee and Kole (2004) studied on 22 genotypes of fenugreek and reveals that grain yield was positively correlated with branches per plant, pods per plant, pod length, seeds per pod, pod weight, biological yield, shelling per cent and harvest index at both phenotypic and genotypic levels.

Sarada *et al*. (2008) investigated twelve genotypes of fenugreek to estimate the correlation coefficients for yield and yield components. The phenotypic and genotypic correlation studied showed that association of seed yield with plant height, number of pods per plant, pod length, and number of seeds per pod was appreciable, indicating the importance of these traits as components for seed yield.

Gangopadhyay *et al.* (2009) carried out an experiment to assess the correlation, path-coefficient, and genetic variability in 40 morphologically diverse accessions of fenugreek (*Trigonella foenum-graecum* L.). Plant height, primary branches, days to 50% flowering, pods per plant, grains per pod, days to maturity, 1000-seed weight and seed yield per plant showed significant differences and wide variations in both the years.

Singh and Pramila (2009) reported correlation and path analysis in 60 (Sixty) promising genotypes of fenugreek indicated that yield per hectare was closely associated with number of grains per pod, length of pod, 1000-grain weight and yield per plot.

Naik *et al.* (2011) studied on thirty-one genotypes of fenugreek (*Trigonella foenum-graecum* L.) to assess the association of different characters with seed yield, their relationship and direct and indirect effect of different characters on seed yield per plant to identify the superior genotype for the further crop improvement programme.

Dashora *et al.* (2011) studied on 48 genotypes of fenugreek and reported that correlation coefficient in biological yield per plot and harvest index exhibited positive and significant correlation with seed yield while days to 50% flowering exhibited negative and significant association with seed yield.

Fikreselassie *et al.* (2012) studied on 143 random samples of fenugreek and revealed that seed yield per plant had positive and highly significant genotypic correlations with plant height, biomass yield per plant, pods per plant, seeds per plant, thousand seed weight, number of days to maturity, grain filling period, number of pods per plant, number of total nodes per plant, number of podding nodes per plant, number of primary branches per plant and number of secondary branches per plant.

Kole *et al.* (2013) studied on thirty diverse genotypes of fenugreek were grown in six (E1 to E6) environments during the winter seasons for three consecutive years from 2002 to 2003 and 2004 to 2005 under high input and low input conditions, created by changing the date of sowing, spacing, fertilizer dose and other crop management practices at the Agriculture Farm of Institute of Agriculture, Visva-Bharati, West Bengal. Analysis of correlations revealed that significant and positive genotypic and phenotypic correlations of pod number, husk weight, stem weight and harvest index with seed yield did not change with the change in environmental conditions. Majority of the characters (except days to flowering and test weight) had significant and positive correlation with seed yield in all the environments except in E3, indicating the scope for selection for improving seed yield of fenugreek. The positive direct effects recorded in genotypic and phenotypic path analysis for pod number, seeds per pod and test weight were consistently greater in all the six environments. Therefore, selection of these characters in positive direction would be effective in increasing seed yield.

2.3 Path coefficient analysis

The path coefficient analysis partitions the correlation coefficient into components of direct and indirect effects, which involves the measurement of influence of one trait upon set of other traits through standardized partial regression coefficients to increase efficiency in selection. Basically, the technique aims to improve a dependant character like yield when the independent characters have significant relation in desirable direction and positive direct or indirect effect through other traits on dependent character.

Pant *et al*. (1984) revealed that path coefficient analysis regarding the direct effects via plant height, number of branches, seeds per pod, number of branches and forage yield were positive, but those for plant height, pod length, beak length and pods per plant were of low magnitude.

Kohli *et al.* (1988) study on the 15 divergent genotypes of fenugreek and reported that path analysis indicated that maximum contribution towards green yield through direct effects of number of shoots per plant (1.05). The higher number of shoots per plant was the single most important character contributing towards green yield and seed yield in fenugreek.

Singh and Raghuvanshi (1989) worked on path coefficient analysis in fenugreek and reveals those days to maturity, branches per plant, seeds per pod and 100 seed weight had direct positive effect on yield per plant.

Mathur (1996) reported that 50 divergent genotypes of fenugreek analysis for path analysis the plant height, number of pods per plant, number of seeds per pod and test weight of utmost importance for contributing yield per plant in fenugreek.

Lowanshi *et al.* (1998) studied on path coefficient analysis for different morphological and sink parameter were carried out in 16 varieties of fenugreek and reported the number of pods per plant had highest direct effect on seed yield, while low positive indirect effects were observed for number of pods per plant via 1000 seed weight.

Dash and Kole (2000) path analysis in a population of 15 genotypes of fenugreek and reported that path coefficient analysis indicated direct positive effects of straw yield, test weight, grains per pod and pods per plant on grain yield per plant.

Saha and Kole (2001) studied on fifteen genotypes of fenugreek and reported that genotypic path analysis had high positive direct effects of branches per plant, straw yield, pod length and pods per plant on grain yield.

Banerjee and Kole (2004) study on different types of 22 genotypes of fenugreek and reported that path analysis on days to flowering, pods per plant, pod length and seeds per pod are the important characters determining seed yield in fenugreek.

Datta *et al.* (2005) reported that phenotypic path coefficient analysis in fenugreek showed that the number of pods per plant had the highest direct effects on seed yield, followed by the number of leaves per plant and number of seeds per pod.

Singh *et al*. (2006) studied on thirty-eight genotypes of fenugreek for the association and contribution of some important traits on seed yield of fenugreek. The path analysis for seed yield revealed that pods per plant had the maximum positive direct effect followed by 100- seed weight, pod length and number of seeds per pod.

Sharma and Sastry (2008) reported that 240 lines along with five promising varieties namely RMt-1, RMt-143, UM-144, UM-303, and local check were evaluated in an augmented block design and revealed that path coefficients analysis on characters such as biological yield, pods per plant and primary branches per plant were the important characters of the selection of high yielding genotypes as they exerted positive direct effects as well as showed positive correlation with seed yield at both genotypic and phenotypic levels.

Singh and Pramila (2009) reported on path analysis in 60 promising genotypes of fenugreek indicated that yield per hectare was closely associated with number of grains per pod, length of pod, 1000-grain weight and yield per plot. Path co-efficient genotypic level revealed that number of grains per pod, number of pods per plant, 1000-grain per pod, number of days to maturity, length of pod and number of days to 50 per cent flowering showed maximum positive direct effect on grain yield per hectare.

Prajapati *et al*. (2010) studied sixty four genotypes of fenugreek and reported that path analysis on number of pods per plant, days to 50% flowering and test weight had highest positive direct effects on grain yield.

Dashora *et al.* (2011) studied the 48 genotypes of fenugreek reveals that Path coefficient on biological yield per plot had highest positive direct effect on seed yield followed by branches per plant, pod length and test weight.

Naik *et al.* (2011) studied on thirty-one genotypes of fenugreek and reported that path coefficient analysis at genotypic and phenotypic level. The number of branches per plant followed by length of branches per plant followed by length of pod, plant height, number of grains per pod, days to 50% flowering and number of pods per plant had positive direct effect on seed yield per plant at phenotypic level.

Fikreselassie *et al.* (2012) studied on 143 random samples of fenugreek and reported the path analysis at genotypic level, the number of seeds per plant and thousand seed weight contributed major positive direct effects on seed yield per plant.

3. MATERIAL AND METHODS

The field experiment entitled “Variability and Correlation Analysis in Fenugreek (*Trigonella foenum-graecum* L.)’’ was conducted during the *Rabi* season of 2012-2013. Details of the method and techniques followed in the experiment are given below.

3.1 Experimental site

The experiment was conducted at Horticulture farm, College of Horticulture, RVSKVV, Mandsaur (M.P.) during the *“rabi*” season of 2012-2013. Mandsaur is situated in Malwa plateau in Western part of Madhya Pradesh at North latitude of 23.45^0 to 24.13^0 and 74.44^0 to 75.18^0 East longitudes and an altitude of 435.02 meters above mean sea level. This region falls under agro climatic zone no.10 of the state.

3.2 Climatic of the Region

` Mandsaur belongs to sub-tropical and semi-arid climatic conditions having a temperature range of minimum 30^0C and maximum 44^0C in winter and summer respectively. In this area maximum rainfall is received during mid June to early October with occasional shower in winter. The average annual rainfall is 797.60 mm. South-West monsoon is responsible for major part of annual precipitation. Meteorological data recorded during the period of investigation are presented in Table 3.1 and are graphically shown in Fig 3.1.

Table 3.1: Weekly meteorological observations during the study period (October, 2012- March, 2013)

Week No.	Duration	Temperature		Relative humidity (%)	Weekly rainfall (mm)	No. of rainy days
		Min.^{0}C	Max.^{0}C			
43	24 Oct-31 Oct.	21.85	35.95	53	-	-
44	01 Oct-07 Nov.	20.64	31.65	49	-	-
45	8 Nov-14 Nov.	20.44	31.55	55	-	-
46	15 Nov-21 Nov.	20.27	30.90	53	-	-
47	22 Nov-28 Nov	19.47	29.00	51	-	-
48	29 Nov-05 Nov	17.30	28.71	57	-	-
49	06 Dec-12 Dec	16.82	29.38	53	-	-
50	13 Dec-19 Dec	16.35	27.38	53	-	-
51	20 Dec-26 Dec	12.82	26.30	33	-	-
1	27 Dec-02 Jan	10.54	24.60	30	-	-
2	03 Jan-09 Jan	6.80	22.17	23	-	-
3	10 Jan-16 Jan	11.97	28.27	30	-	-
4	17 Jan-23 Jan	8.48	26.25	27	-	-
5	24 Jan-30 Jan	9.85	27.21	30	-	-
6	31 Jan -06 Feb	16.04	27.14	33	-	-
7	07 Feb-13 Feb	16.24	28.20	42	-	-
8	14 Feb-20Feb	16.50	29.00	43	-	-
9	21 Feb-27 Feb	14.20	28.20	34	-	-
10	28 Feb -06 March	14.50	30.30	36	-	-
11	07 March-14 March	15.8	33.30	48	-	-
12	15 March-21 March	16.60	36.10	52.		

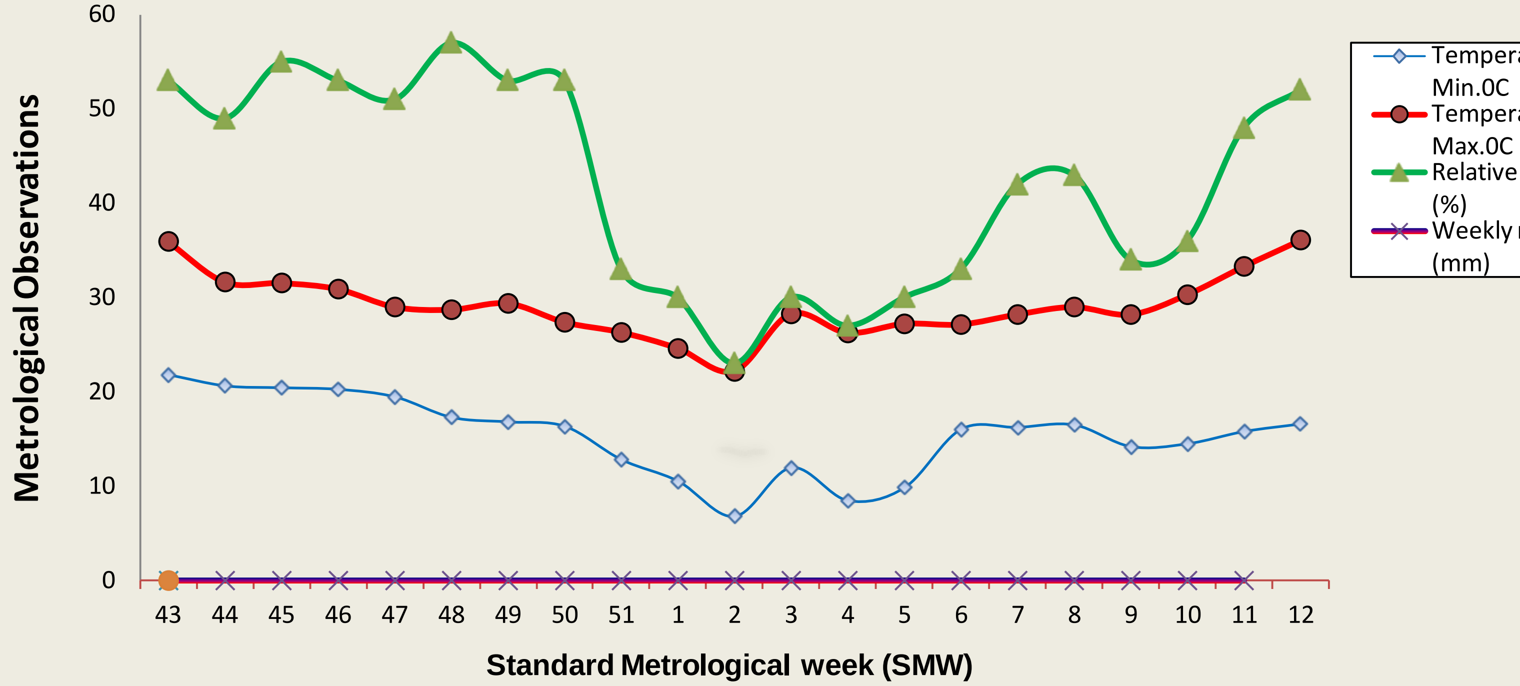
3.3 Soil characteristics of the experimental site

To ascertain physico-chemical characteristics of the soil during the year of study, soil samples from 0-15 cm depth were taken from different spots of the experimental field before application of fertilizer. A representative composite sample was prepared by processing and mixing them together and the sample was analyzed for physical and chemical properties. The result of analysis, presented in Table 3.2, showed that the soil was light black loamy in texture, with low in availability of nitrogen, medium in phosphorus and high in potassium status

Table 3.2: Physical and Chemical Composition of the Soil

S.No.	Particulars	Value obtained	Methods
Physical Characters			
(a) (b) (c)	Sand % Silt% Clay%	35% 42% 28%	By international Pipette method (Piper, 1950.)
Chemical Characters			
(a)	Soil pH	7.2	Method No. 4, USDA Hand Book No.60 (Richards, 1956)
(b)	Electric conductivity (dSm^{-1})	0.35	EC meter
(c)	Available nitrogen (kg ha^{-1})	243.2 (low)	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)
(d)	Available phosphorus (kg ha^{-1})	19.75 (medium)	Olsen extraction method (Olsen *et al.* 1954)
(e)	Available potassium (kg ha^{-1})	448.0 (high)	Flame photometer method (Metson,1956)

Fig. 3.1 Weekly metrological observations during the study period (oct. 2012 to mar. 2013)



3.4 Experimental Details

1.	Location	Bahadari Farm, College of Horticulture Mandsaur (M.P.)
2.	Crop	Fenugreek
3.	Season	Rabi season 2012-13
4.	Design	Randomized Block Design
5.	Number of treatments	30
6.	Number of Replication	3
7.	Number of Row per plot	5
8.	Total Number of plots	90
9.	Row to Row distance	40 cm
10.	Plant to plant distance	20 cm
11.	Replication distance	100 cm
13.	Experimental area	37 m x 15.5m = 573.5 m^2
14.	Plot area	2 m X 2 m = 4 m^2
16.	Date of sowing	24 October, 2012
17.	Date of Harvesting	17 March, 2013

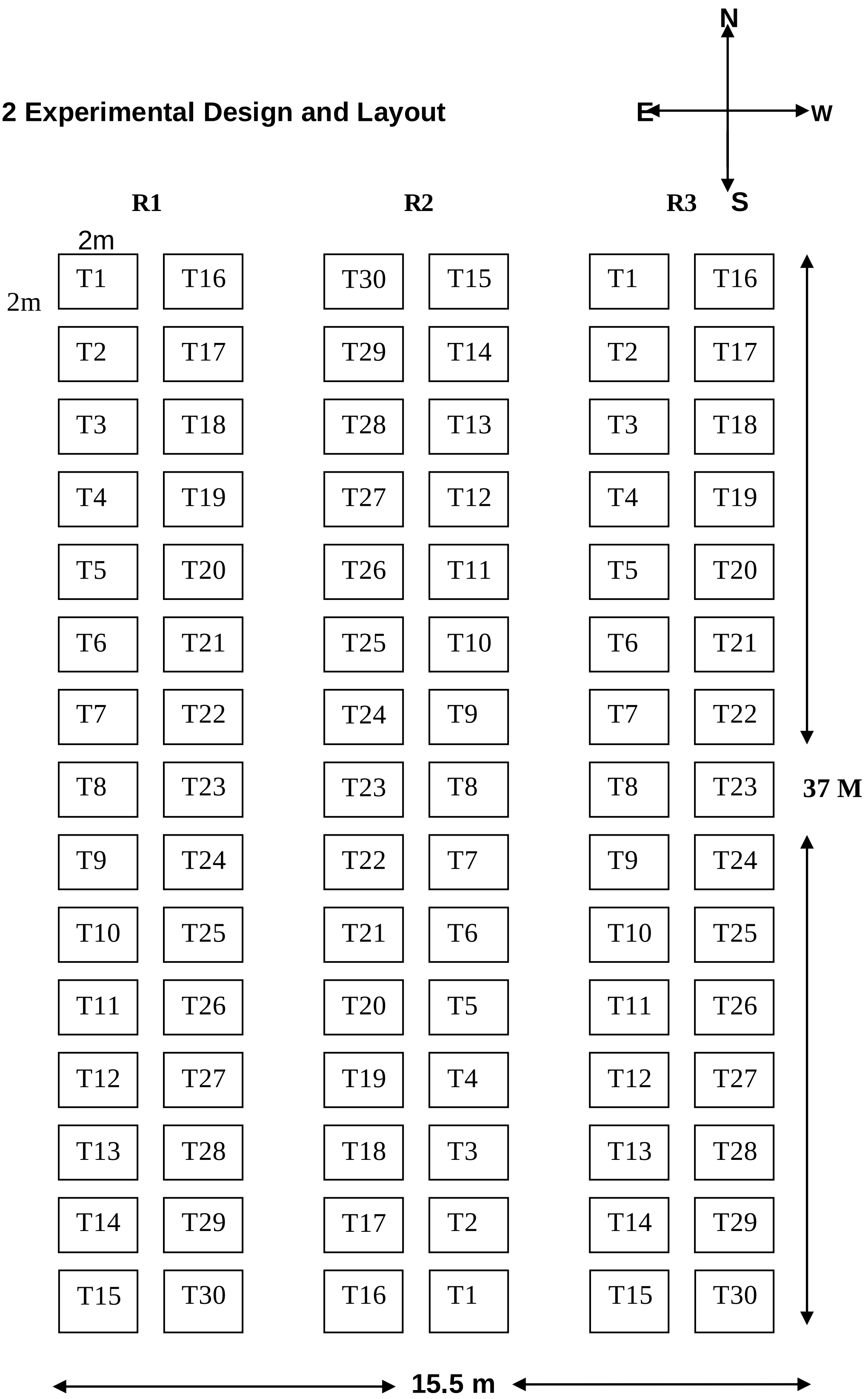
3.5.1 Experimental Materials

The experiment was conducted in a randomized block design with 30 treatments and replicated thrice. The randomization of treatments was done with the help of random number table as shown in the plan of layout Fig 3.5.2.

Table 3.3 Details of genotypes.

T1	UM-34	T16	Local-3
T2	UM-19	T17	UM-303
T3	UM-17	T18	UM-116
T4	Rmt-143	T19	UM-352
T5	UM-30	T20	NRCSS-AM-2
T6	UM-5	T21	Local-1
T7	UM-27	T22	UM-351
T8	UM-29	T23	Rmt-305
T9	Rmt-351	T24	UM-14
T10	UM-36	T25	UM-2
T11	UM-7	T26	UM-35
T12	Rmt-1	T27	UM-18
T13	UM-1	T28	Rmt-303
T14	UM-32	T29	AFg-1
T15	Local-2	T30	AFg-2

3.5.2 Experimental Design and Layout



3.6 Cultural Operations

3.6.1 Field Preparation

The field was properly ploughed by disc harrow and then pulverized discing and harrowing. Then after field was leveled properly with heavy wooden planker by tractor and then plots were prepared according to the layout plan.

3.6.2 Application of Manure and Fertilizer

After final preparation of land FYM @ 20 t/ha was mixed thoroughly in soil where as chemical fertilizers *viz*., N, P and K @ 25:60:40 kg/ha were applied in furrow at the time of sowing

3.6.3 Seed and Sowing

Required seed of different fenugreek varieties was treated by Thiram @2.5 g/kg of seed and immediately sown in furrow at the depth of 2 to 3 cm followed by a light irrigation.

3.6.4 Thinning

Thinning of the crop was done 25-30 days after germination of crop in order to maintain proper spacing and plant population in plots.

3.6.5 Weeding and hoeing

After date of sowing four weeding and hoeing were done manually, first at 15 DAS, second 30 DAS, third 45 DAS and fourth 60 days after sowing to control the seasonal weeds.

3.6.6 Plant Protection Measures

In order to safe guard the plants against aphids, one spray of Dimethoate @ 2ml per liter of water and one spray of Emidachloroprid @ 2 ml per liter water and fungicide – Sulfex @ 3g per liter of water was sprayed to prevent the crop from powdery mildew and Dithane M-45 @ 2 g per liter was sprayed to prevent the crop from Downey mildew.

3.6.7 Irrigation

First irrigation was given just after sowing followed by light irrigation at 12 days after sowing to facilitate proper germination and establishment of the crop seedling. Subsequent irrigation was given almost at fortnightly intervals as per need of the crop.

Table 3.4 Irrigation scheduling

S. No.	Irrigation	Date of irrigation
1.	First	24 October 2012
2.	Second	06 November 2012
3.	Third	21 November 2012
4.	Fourth	18 December 2012
5.	Fifth	10 January 2013
6.	Sixth	03 February 2013
7.	Seventh	22 February 2013

3.6.8 Harvesting

The crop was harvested with the help of sickle from March 17, 2013, the harvested material of each plot was tied up in bundles and tagged and kept on the threshing floor for sun drying.

3.6.9 Threshing and Winnowing

After shade drying the threshing of the individuals plot was done with the help of wooden sticks and winnowed traditionally to separate seed and straw. Plot wise seed were taken for weighing. Seed and straw were separated for further analysis.

3.6.10 Observation to be taken during course of investigation

A. Growth Characteristic

1. Days taken to 50% flowering.
2. Plant height (cm) at 30, 60 and 90 DAS.
3. Number of branches per plant at 90 DAS.
4. Dry weight per plant at initiation of flowering.

B. Yield characteristics

1. Number of pods per plant.
2. Number of seeds per pod.
3. 1000 seeds weight (g).
4. Biological yield (g).
5. Seed yield per plant (g).
6. Dry matter content (g).
7. Length of pods (cm).
8. Harvest index.
9. Straw yield per plant (g).

C. Quality characteristics

1. Protein content in seed (%).
2. Chlorophyll content in leaves (%).

3.6.11 Observation and Procedure

Observation was recorded on the different parameters *viz*. Growth, yield and quality characteristics of fenugreek.

3.6.12 Sampling Technique

Five plants were randomly selected (tagged) from each plot for taking the observation on various characters.

3.6.13 Growth Parameters

1. Plant Height (cm)

Five plants were randomly selected from each plot. They were measured at 30, 60, and 90 DAS. The plant height was measured from the ground level to the tip of the main shoot. The average was taken out and expressed as plant height in cm.

2. Number of branches per plant

The number of branches of five randomly selected plants was count at 90 DAS.

3. Days taken to 50 per cent flowering

Days taken to 50 percent flowering in each treatment were recorded after first flowering on the basis of visual observation. Three central rows were selected in each plot and completion of flowering on 50 per cent plants was recorded. Based on the date, a day taken to 50 percent flowering was worked out for each plot.

4. Dry weight per plant (g)

After taking fresh weight at initiation of flowering and maturity stage, five plants were kept in hot air oven at 65 $\pm$ 5^0C temperature for drying till constant weight. Final weight was noted in gram.

3.6.14 Yield and Yield Parameters

1. Number of pods per plant

Total number of pods of five randomly selected plants was noted at the time of harvesting.

2. Number of seeds per pod

Five randomly selected pods of five randomly selected plants were punctured through the suture and the number of seeds was counted.

3. Pod length (cm)

The length of pods was measured with the help of thread and scale and average was calculated from five randomly selected plants.

4. 1000 Seed weight (g)

One thousand seeds were counted in samples taken from the finally winnowed and cleared produce of each plot after weighing. These seeds were weighed on electronic balance and the weight was recorded as test weight (g).

5. Seed Yield per plant (g)

After threshing and winnowing clean seed were obtained from individual plant. They were weighed and the weight was recorded in gm per plant. This was then converted into gm per plot. These seeds were weighed on electronic balance and the weight was recorded as test weight (g).

6. Dry matter content (g)

Five plants randomly selected and removed from each experiment unit at harvest time. The dry matter was weighed and average was worked out and expressed as g/plant.

7. Biological yield per plant (g)

The crop was harvested and sun dried from each plot and the tagged five plants from each plot were weighed and recorded as biological yield in g/plant.

8. Harvest index (Beadle 1982)

Harvest index is the ratio of economic yield and biological yield.

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

9. Straw yield per plant (g)

Straw yield is calculated in the basic of biological yield and seed yield. When seed is subtracted from biological yield we obtain straw yield.

Straw yield per plant (g) = Biological yield per plant – Seed yield per plant

3.6.15 Quality characteristics

1. Protein content in seed (%)

Procedure for analysis of total nitrogen in dried seed samples

Reagents

1. Copper sulphate
2. Potassium sulphate
3. 40 % and N/20 N_aO_H
4. N/20 H_2SO_4
5. Phenolphthalein indicator

Method

(i) 1g of grained plant sample was taken in digestion tube and 10 ml of concentrated sulphuric acid (H_2So_4) was added in each tube.

(ii) Then potassium sulphate (K_2So_4) and copper sulphate ($CuSo_4$) was added in the ratio 5:2 (3g / sample).

(iii) The digestion tube was placed on the digestion block and set the digestion system to a temperature of 400-410 ^{0}C.

(iv) The digestion was continued till black or brown colour of the sample disappears and clear solution is formed. Afterwards the samples were allowed to cool at room temperature.

(v) The digested sample tube was placed in the distillation unit and distillation was done using 40% NaOH solution.

(vi) 10 ml of 4% boric acid solution was taken in a conical flask containing methyl red and methyl green indicator and dipped the condenser outlet in the flask.

(vii) After distillation, boric acid solution is titrated against 0.1 N HCl. Blank is also run and titration is carried out to the same end point as that of the sample.

(viii) The nitrogen content in plant samples is calculated as follows:

$$\text{Nitrogen (\%)} = \frac{\text{(Sample reading – Blank reading) x Normality of HCl x14 x100}}{\text{Weight of sample (g) x 1000}}$$

Crude protein (%) = Nitrogen (%) x 6.25

2. Chlorophyll content in leaves (%)

Five plants randomly selected and observed the SPAD mater unit and recorded the Chlorophyll content in plant.

3.7 Statistical Analysis

The experimental data recorded were subjected to statistical analysis using analysis of variance technique suggested by Panse and Sukhatme (1985). The critical differences for the treatments comparison were worked out, wherever the “F” test was found significant at five per cent level of significance. To elucidate effects, summery tables along with S.Em± and critical differences is given in chapter “Experimental results” and their analyses of variance are given in the appendices at the end.

The enlisted data were analyzed statistically as suggested by Fisher (1954) for analysis of variance and means of genotypes were compared at 5 percent level of significance.

The data obtained in respect of all the characters has been subjected to the following statistically analysis

1. Estimation of genetic variability.
2. Estimation of correlation coefficient.

Table 3.5 ANOVA for Randomized block design.

Source of Variation	D. F.	S. S	M. S.S.	Expected of MSS	F $_{ref.}$ 5% or 1%
Replication	(r –1)=2	SSR	MSR	$\sigma^2e + g\,\sigma^2r$	
Genotypes	(t – 1)=29	SSG	MSG	$\sigma^2e + r\,\sigma^2g$	
Error	(r-1) (t -1)=58	SSE	MSE	σ^2e	
Total	(rt –1)=89				

Where

r = Number of replication

t = Number of treatment

D.f. = Degrees of freedom

S.S = Sum of squares

MSS = mean sum of square

RSS = replication sum of square

GSS = Genotypes sum of square

ESS = Error sum of square

RMS = Replication mean sum of square

GMS = Genotypes mean sum of square (Mv)

$\sigma^2 e$ = Error variance = MSE/r

$\sigma^2 p$ = Phenotypic variance = $\sigma^2 e + r\,\sigma^2 g$

$\sigma^2 g$ = Genotypic variance = (MSG-MSE)/r

$$SE\ (m) = \frac{\text{Error variance}}{\text{Number of replication}}$$

The standard error of difference of mean was calculated as follows:

$$SE\ (d) = \sqrt{\frac{2 \times \text{Error variance}}{\text{Number of replication}}}$$

The critical difference to test the difference between two mean values was calculated as follows: -

CD 5% = SE x t value at 5% Level of significance at error df.

CD 1% = SE x t value at 1% Level of significance at error df.

(a) Environmental variance

$$\sigma^2 e = \frac{Me}{r}$$

(b) Genotypic variance.

$$\sigma^2 g = \frac{Mv - Me}{r}$$

(c) Phenotypic variance.

$$\sigma^2 p = \sigma^2 g + \sigma^2 e$$

1. Estimation of genetic variability

Various parameters of genetic variability viz., mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variance (GCV), broad sense heritability, genetic advance and genetic advance as a percentage of mean were worked out.

2. Coefficient of variation (CV)

Genotypic and phenotypic coefficient of variation was computed for each trait using the formula given by Burton (1952) and expressed in term of percentage: -

$$\text{Phenotypic coefficient of variation (PCV \%)} = \frac{\sigma p}{\overline{X}} \times 100$$

$$\text{Genotypic coefficient of variation (GCV \%)} = \frac{\sigma g}{\overline{X}} \times 100$$

Where,

σp = phenotypic standard deviation

σg = genotypic standard deviation

$\overline{X}$ = General mean of the character under consideration

Where,

σp = phenotypic standard deviation

$\overline{X}$ = General mean of the character under consideration

3. Estimation of heritability (Broad sense)

Heritability in broad sense was estimated according to the formula given by Hanson *et al*. (1956).

$$h^2 \text{ (BS)} = \frac{\sigma^2 g}{\sigma^2 p} \text{ X100}$$

Where,

h^2 (BS) = heritability (broad sense)

σ^2p = phenotypic variance

σ^2g = genotypic variance

4. Estimation of genetic advance

The genetic advance was calculated as suggested by Lush (1949) and Johnson *et al*., (1955) using formula.

Genetic advance (GA) = K. σp. h^2 (BS)

Where,

K = constant (2.06) at 5% selection intensity

σp = phenotypic standard deviation

h^2 (BS) = Broad sense heritability

Genetic advance as a percentage of mean was calculated as per formula given below.

$$\text{GA as a percentage of mean} = \frac{GA}{\bar{X}} \times 100$$

5. Estimation Correlation Coefficient of Analysis

The genotypic and phenotypic correlations were calculated in parents and the crosses by substituting the corresponding variance and covariance components in the following formulae giving by Al. Jibouri *et al.* (1958).

1. Genotypic correlation coefficient(rg)= $\dfrac{\text{Genotypic Cov (XY)}}{[(\text{GenoVar. X})(\text{Geno Var. Y})]^{1/2}}$

2. Phenotypic correlation coefficient(rp)= $\dfrac{\text{Phenotypic Cov (XY)}}{[(\text{PhenoVar.X})(\text{PhenoVar.Y})]^{1/2}}$

The test of significance of phenotypic correlation was carried out by t.

$$\text{'t'} = r \sqrt{\frac{n-2}{1-r^2}} \text{ at } n-2 \text{ df}$$

Correlation coefficient (r) is another measure of the association between two or more than two variables. It however, does not measure the dependence of one variable over the other. It is in-fact the measure of symmetrical association between variables.

Symbolically,

$$rxy = \frac{\text{Cov. (XY)}}{\sqrt{\text{V (X) V (Y)}}}$$

Where,

rxy	= is the correlation coefficient between x and y
Cov. (xy)	= is the covariance between X and Y
V(x)	= is the variance of X and
V(y)	= is the variance of Y

6. Path coefficient analysis

The cause and effect relationship is well defined in path coefficient analysis it is possible to represent the whole system of variables in the form of a diagram known as path diagram. Path coefficient analysis can be defined as the ratio of the standard deviation of the effect due to a given cause to the total standard deviation of the effect, in other words it is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects, *i.e*. it measures the direct and indirect contribution of various independent characters on a dependent character

Designing new plant type, the knowledge of direct and indirect influence of yield contributing characters, path coefficient analysis was under taken in parents and crosses. Wright (1921) proposed the original technique this analysis was carried out by modified method devised by Dewey and Lu (1959). Following set of simultaneously equations were formed and solved for estimating direct and indirect effects.

Direct effect:

r15= P15+r12.P25+r13.P35+r14.P45

r25=r12.P15+P25+r23.P35+r24.P45

r35=r13.P15+r23.P25+P35+r34.P45,and

$r_{45}=r_{14}.P_{15}+r_{24}.P_{25}+r_{34}.P_{35}+P_{45}$

Where, r_{12}, r_{13}, r_{14}, etc. are the estimates of simple correlation coefficient between variables X_1 and X_2, X_1 and X_3, X_1 and X_4, etc., respectively, and P_{15}, P_{25}, P_{35} and P_{45} are the estimates of direct effects of variable X_1, X_2, X_3 and X_4, respectively, on the dependent variable

Residual effect was obtained as per for formula given below –

$$R = \sqrt{1 - \Sigma d_i r_{ij}}$$

Where,

d_i = Direct effect of the i^{th} character

r_{ij} = Correlation coefficient of the i^{th} character with j^{th} character.

4. RESULTS

The results of the field experiment entitled “Variability and Correlation Analysis in Fenugreek (*Trigonella foenum-graecum* L.)” conducted at College of Horticulture, Mandsaur, M.P. during the Rabi season of 2012-2013, are being presented and described in this chapter. Data pertaining to various criteria used for evaluation of the treatments were statistically analyzed and analysis of variance for these data has been furnished in appendices. Interpretation of data has been made on the mean basis. The results are presented under the following sections:

A. Growth parameters

B. Yield parameters

C. Quality parameters

D. Study of genetic parameters

1) Genetic variability

2) Heritability

3) Genetic advance as percentage of mean

E. Correlation coefficient studies

F. Path coefficient analysis

A. GROWTH PARAMETERS: The results obtained are presented in Table 4.1, showed wide range for the characters under study.

4.1 Plant height (cm): The mean maximum plant height per plant was recorded at 90 days after sowing. Plant height at 90 DAS, RMT-143 (74.83cm) had shown the highest plant height followed by UM-36 (74.37cm), UM-30 (72.10cm) while the lowest was observed in RMT-305 (46.20cm) had shown the lowest plant height.

4.2 Number of branches per plant: Number of branches per plant was recorded at 90 DAS after sowing. At 90 DAS RMT-305 (16.20) had shown the highest number of branches followed by NRCSS-AM-2 (16.19), RMT-143 (16.14).While, UM-27 (11.23) had shown the lowest number of branches.

4.3 Dry weight of plant at flower initiation (g): Dry weight of plant at flower initiation was recorded highest in AFg-2 (5.27g) followed by UM-36 (5.23g), RMT-143 (5.17g).While, Local-1 (2.23g) had shown the lowest dry weight of plant.

4.4 Days to 50% flowering: Days to 50% flowering in each genotype was recorded on the basis of visual observation. 50% flowering was completed first in genotype RMT-305 (43.67days) followed by Local-1 (44.67days), RMT-143 (44.67days) and highest was completed (53.33days) in genotype UM-34.

B. YIELD PARAMETERS: The results obtained are presented in Table 4.1, showed wide range for the characters under study.

4.5 Number of pods per plant: The mean maximum number of pods per plant at harvest was recorded in genotypes RMT-143 (80.14) followed by UM-36 (79.13), UM-29 (78.37).The lowest number of pods per plant was recorded in genotype RMT-303 (51.10).

4.6 Number of seeds per pod: The highest number of seeds per pod (17.47) was found in genotype RMT-143, followed by UM-36 (17.10) and UM-7 (17.00). The lowest number of seed per pod (13.86) was recorded in genotype UM-35.

4.7 Pod length (cm): The maximum pod length (12.19cm) was found in genotype UM-7, followed by UM-36 (11.83cm), RMT-143 (11.80cm). The minimum pod length (9.82cm) was recorded in genotype UM-352

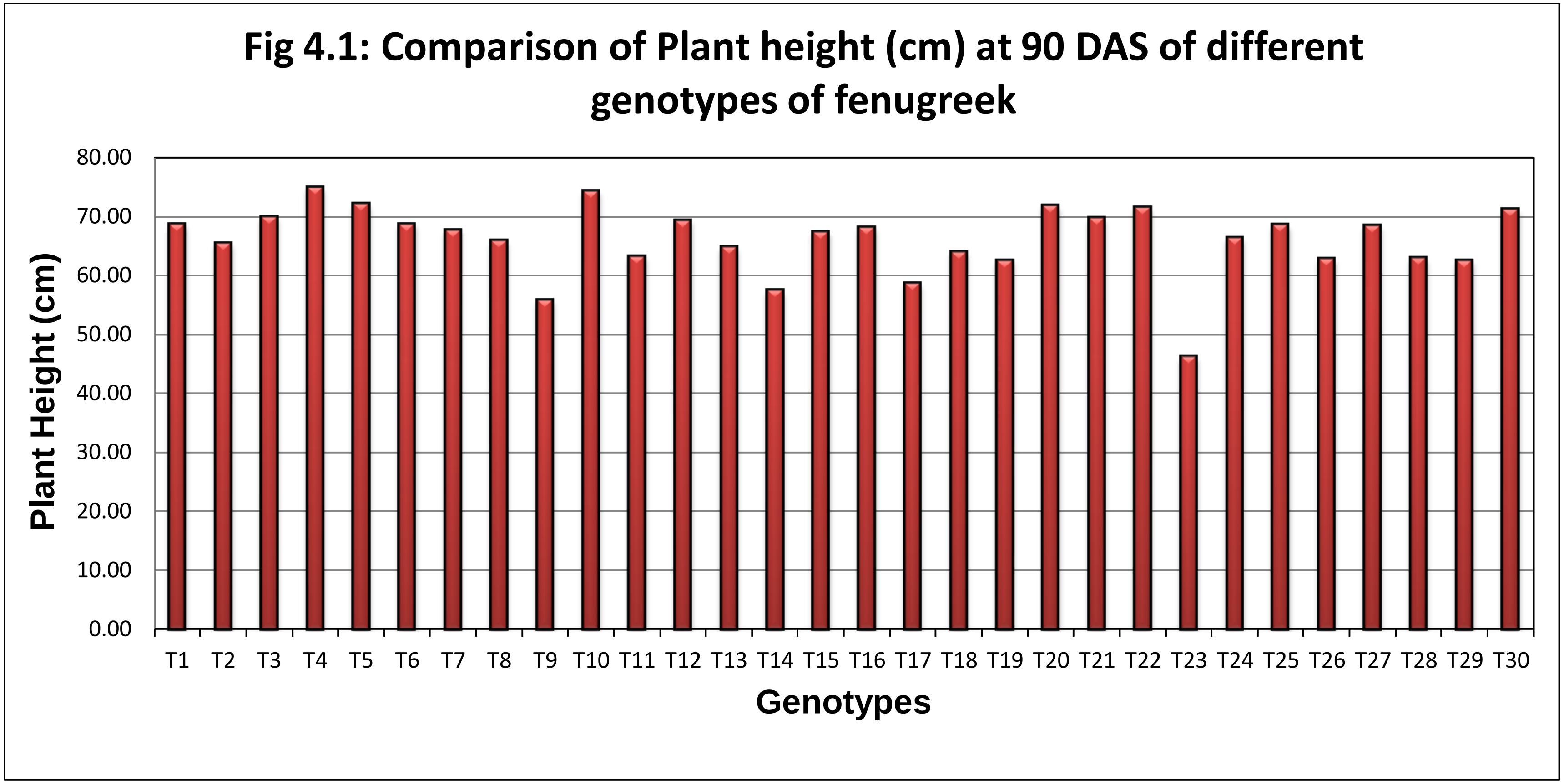


Fig 4.1: Comparison of Plant height (cm) at 90 DAS of different genotypes of fenugreek
Plant Height (cm)
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

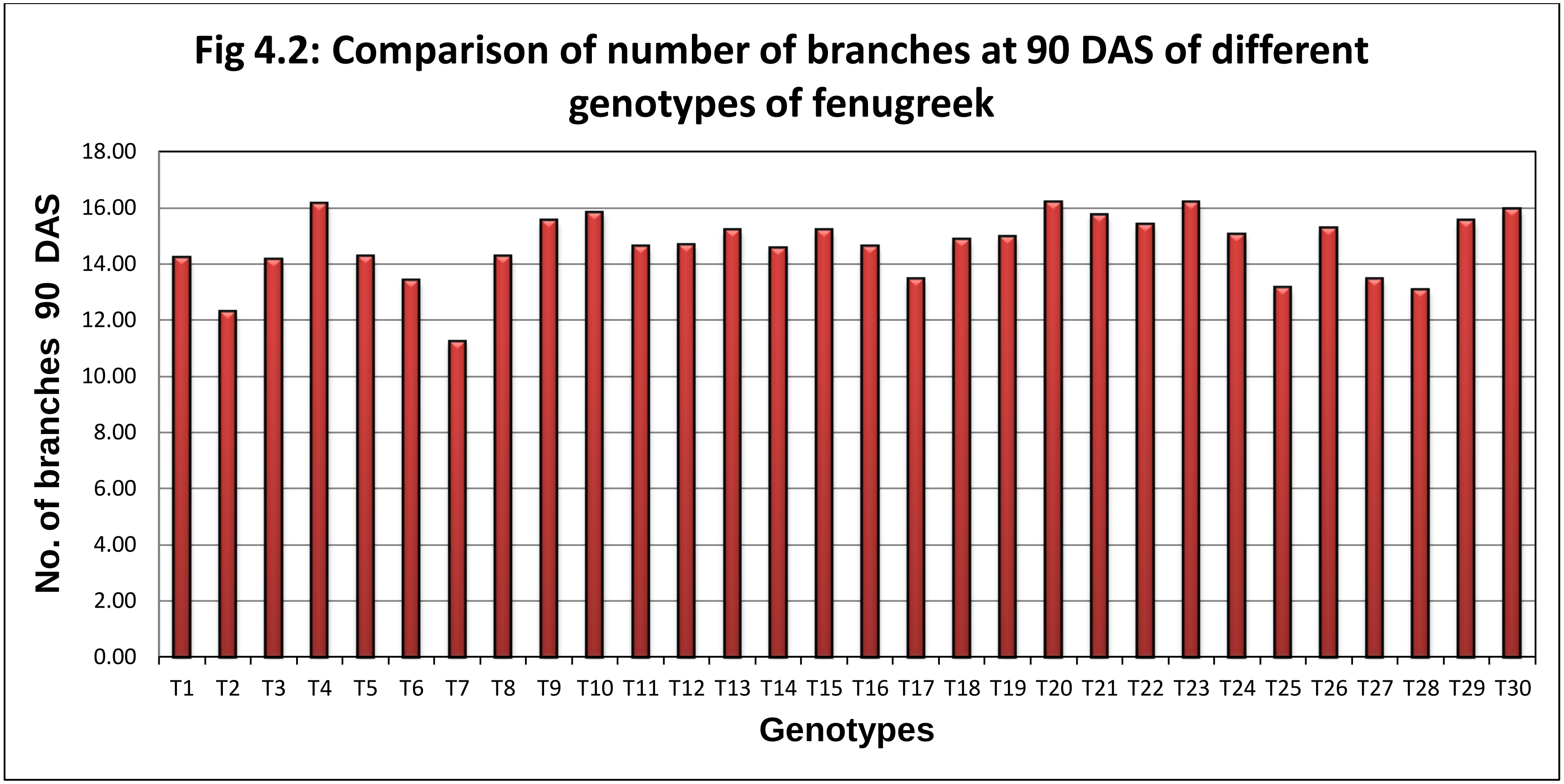
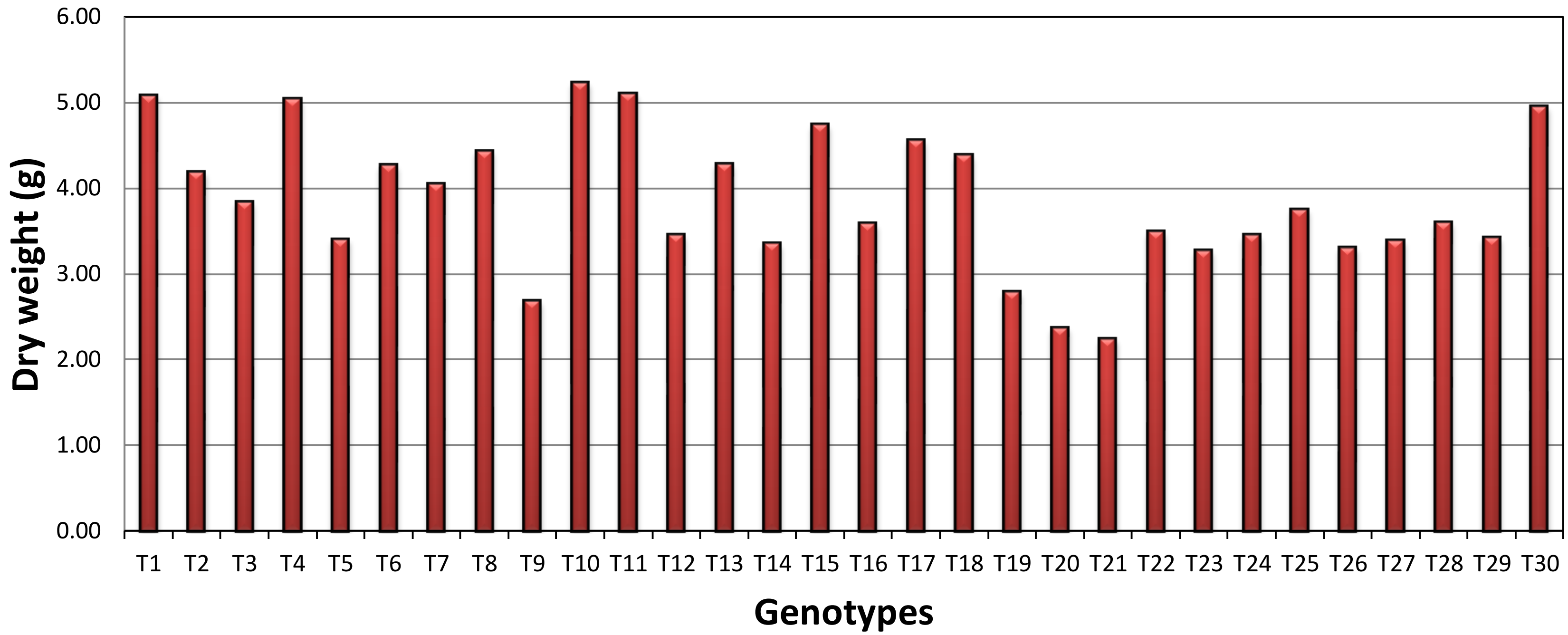


Fig 4.2: Comparison of number of branches at 90 DAS of different genotypes of fenugreek
No. of branches 90 DAS
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

Fig 4.3: Comparison of dry weight at flower initiation (gm) of different genotypes of fenugreek



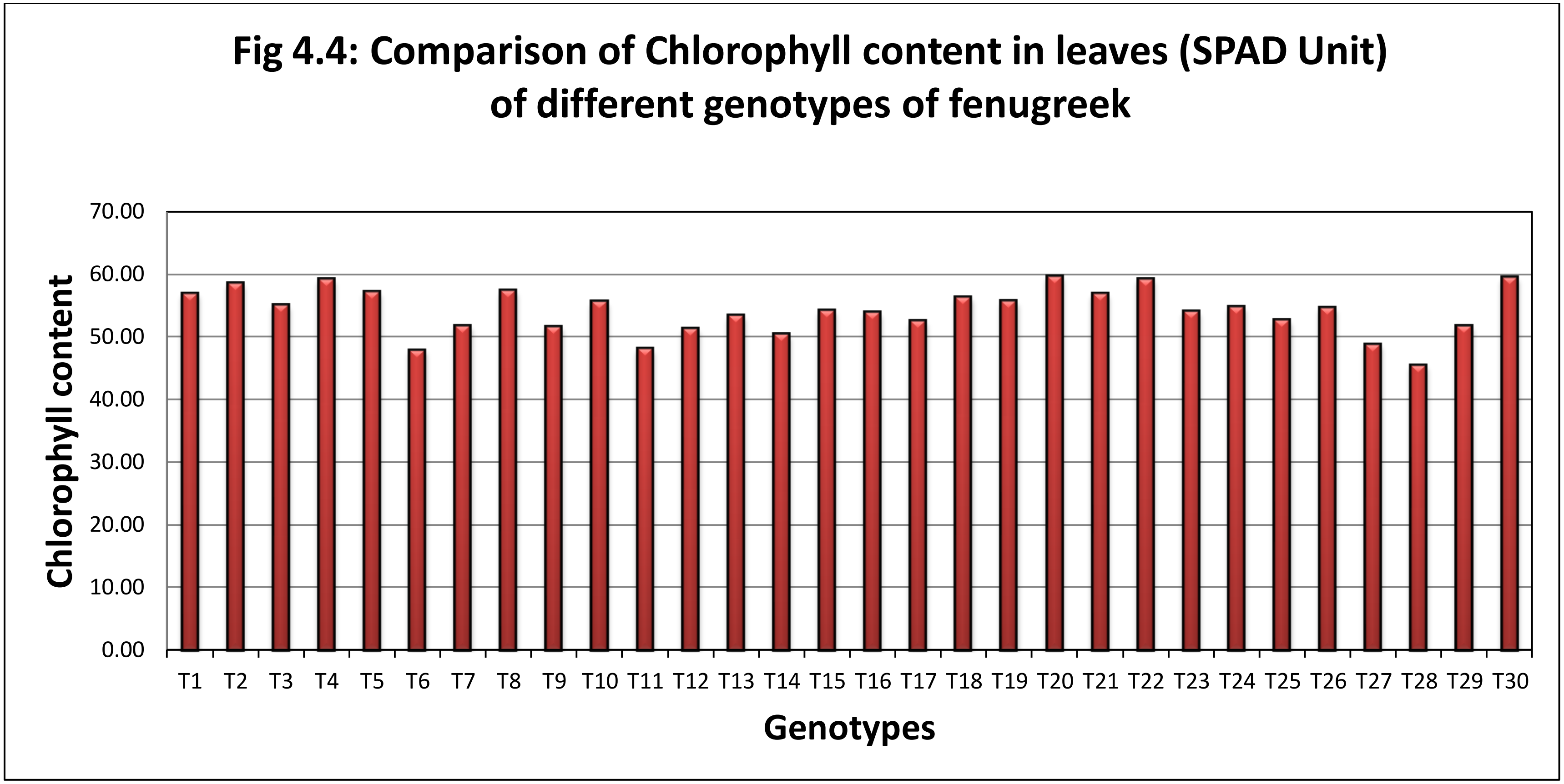


Fig 4.4: Comparison of Chlorophyll content in leaves (SPAD Unit)
of different genotypes of fenugreek
Chlorophyll content
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

Table 4.1: Mean performances of fenugreek genotypes

Genotypes	Plant height (cm)	No. of branches/ plant	Dry wt at flower initiation (g)	Chlorophyll content in leaves (SPAD Unit)	No. of pods/ Plant	No. of seeds/ Pod	Pod length (cm)	Biological yield/plant (g)	Straw yield per plant (g)	Protein content in seed (%)	Days to 50% flowering	1000 seed wt (g)	Dry matter content (g)	Harvest index	Seed yield /plant (g)
UM-34	68.67	14.22	5.08	56.87	59.39	15.86	11.35	33.93	22.95	15.43	53.33	15.05	42.44	32.60	10.98
UM-19	65.43	12.27	4.18	58.53	66.17	14.84	10.59	35.34	23.30	18.17	47.33	13.55	44.90	34.23	12.04
UM-17	69.87	14.13	3.83	55.00	76.30	15.22	11.57	42.67	26.98	15.03	43.67	14.95	68.44	36.73	15.68
RMT-143	74.83	16.14	5.17	59.20	80.14	17.47	11.80	46.37	29.33	25.33	44.67	17.93	75.23	36.74	17.03
UM-30	72.10	14.27	3.40	57.13	68.63	16.21	11.48	40.70	28.40	19.83	47.67	15.63	62.23	30.28	12.30
UM-5	68.73	13.40	4.27	47.83	61.13	16.39	11.34	32.60	21.35	16.37	47.67	13.90	53.63	34.50	11.25
UM-27	67.70	11.23	4.05	51.73	52.12	14.60	11.79	36.17	25.07	15.23	47.67	14.00	63.19	30.69	11.10
UM-29	65.83	14.27	4.43	57.33	78.37	15.73	11.43	45.13	32.27	17.70	48.00	13.07	71.29	28.51	12.87
RMT-351	55.77	15.53	2.68	51.60	59.62	15.80	10.80	31.20	19.02	20.81	51.00	11.33	48.58	39.04	12.18
UM-36	74.37	15.83	5.23	55.60	79.13	17.10	11.83	46.83	31.60	24.68	46.67	19.10	75.17	35.28	16.22
UM-7	63.20	14.60	5.10	48.00	71.23	17.00	12.19	36.07	22.85	19.37	48.00	13.65	54.71	36.65	13.22
RMT-1	69.33	14.67	3.45	51.30	78.25	14.82	10.68	41.83	29.67	17.97	49.00	13.70	62.99	29.09	12.17
UM-1	64.80	15.20	4.28	53.33	74.63	16.89	11.05	38.97	26.53	19.35	49.00	14.00	49.68	31.87	12.43
UM-32	57.43	14.53	3.35	50.37	78.13	14.79	10.91	46.60	33.62	16.58	49.00	13.33	53.99	27.79	12.98
LC-2	67.40	15.20	4.73	54.17	71.00	14.33	10.24	39.27	27.05	18.24	45.33	15.90	55.95	31.31	12.22
LC-3	68.10	14.60	3.58	53.87	66.43	15.34	10.93	33.80	23.80	17.35	48.67	15.80	51.12	30.07	10.00
UM-303	58.60	13.47	4.55	52.50	52.67	15.55	10.69	33.00	23.51	16.06	49.67	13.25	50.72	31.99	10.56
UM-116	63.93	14.87	4.38	56.33	62.27	13.93	10.28	26.63	18.62	18.62	49.67	12.57	42.85	37.59	9.77
UM-352	62.53	14.97	2.78	55.67	72.84	15.69	9.82	42.37	30.18	18.57	49.67	14.73	60.71	28.76	12.19
Nrcssam-2	71.77	16.19	2.37	59.63	69.97	15.33	11.39	41.23	28.20	20.95	48.00	16.93	59.68	31.58	13.03
LC-1	69.67	15.73	2.23	56.80	58.20	14.67	10.69	36.10	24.05	14.03	44.67	15.77	45.78	33.53	12.05
UM-351	71.47	15.40	3.49	59.23	62.97	13.88	11.07	41.40	27.82	17.62	48.67	17.20	64.60	33.03	13.58
RMT-305	46.20	16.20	3.27	54.07	60.78	15.31	10.82	29.80	20.33	20.63	43.67	14.13	39.92	42.66	12.68
UM-14	66.27	15.03	3.45	54.73	70.85	14.44	10.71	38.23	24.90	16.35	48.00	13.50	53.12	34.89	13.33
UM-2	68.47	13.13	3.75	52.60	59.83	15.15	11.52	26.20	17.17	17.91	48.67	13.15	39.53	39.56	10.28
UM-35	62.73	15.27	3.30	54.60	69.13	13.86	10.72	37.92	26.10	22.13	52.00	11.10	56.67	31.14	11.82
UM-18	68.33	13.47	3.38	48.80	55.17	16.15	11.80	27.03	13.50	21.13	45.67	13.85	64.72	50.24	13.53
RMT-303	62.87	13.07	3.60	45.47	51.10	16.10	10.50	28.13	17.62	19.60	49.33	12.50	53.14	37.54	10.52
AFg-1	62.47	15.53	3.42	51.67	63.17	15.82	11.57	33.87	22.53	21.70	47.67	12.08	61.14	33.40	11.34
AFg-2	71.47	15.93	5.27	59.47	72.67	16.98	11.77	44.60	29.35	24.67	48.67	17.15	68.47	34.61	15.43
C D at 5%	4.767	2.190	0.466	2.286	2.599	1.090	1.116	5.094	4.741	0.834	2.250	2.574	13.98	5.845	1.823
S.Em ±	1.683	0.773	0.164	0.807	0.918	0.385	0.394	1.779	1.674	0.294	0.795	0.909	4.938	2.065	0.643
CV	4.419	9.171	7.406	2.585	2.382	4.304	6.149	8.393	11.64	2.699	2.867	10.90	15.21	10.45	8.928

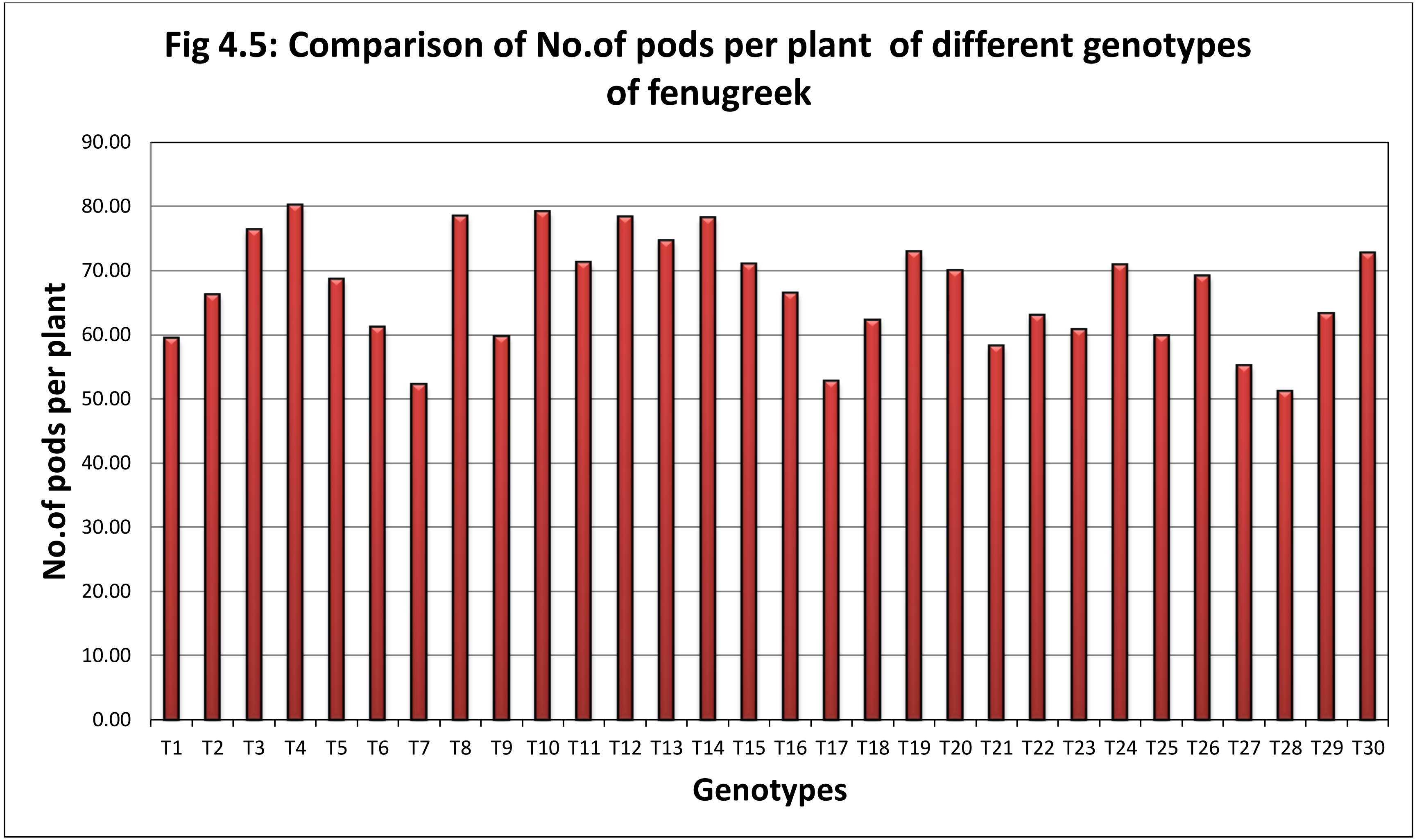


Fig 4.5: Comparison of No.of pods per plant of different genotypes of fenugreek
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
No.of pods per plant
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

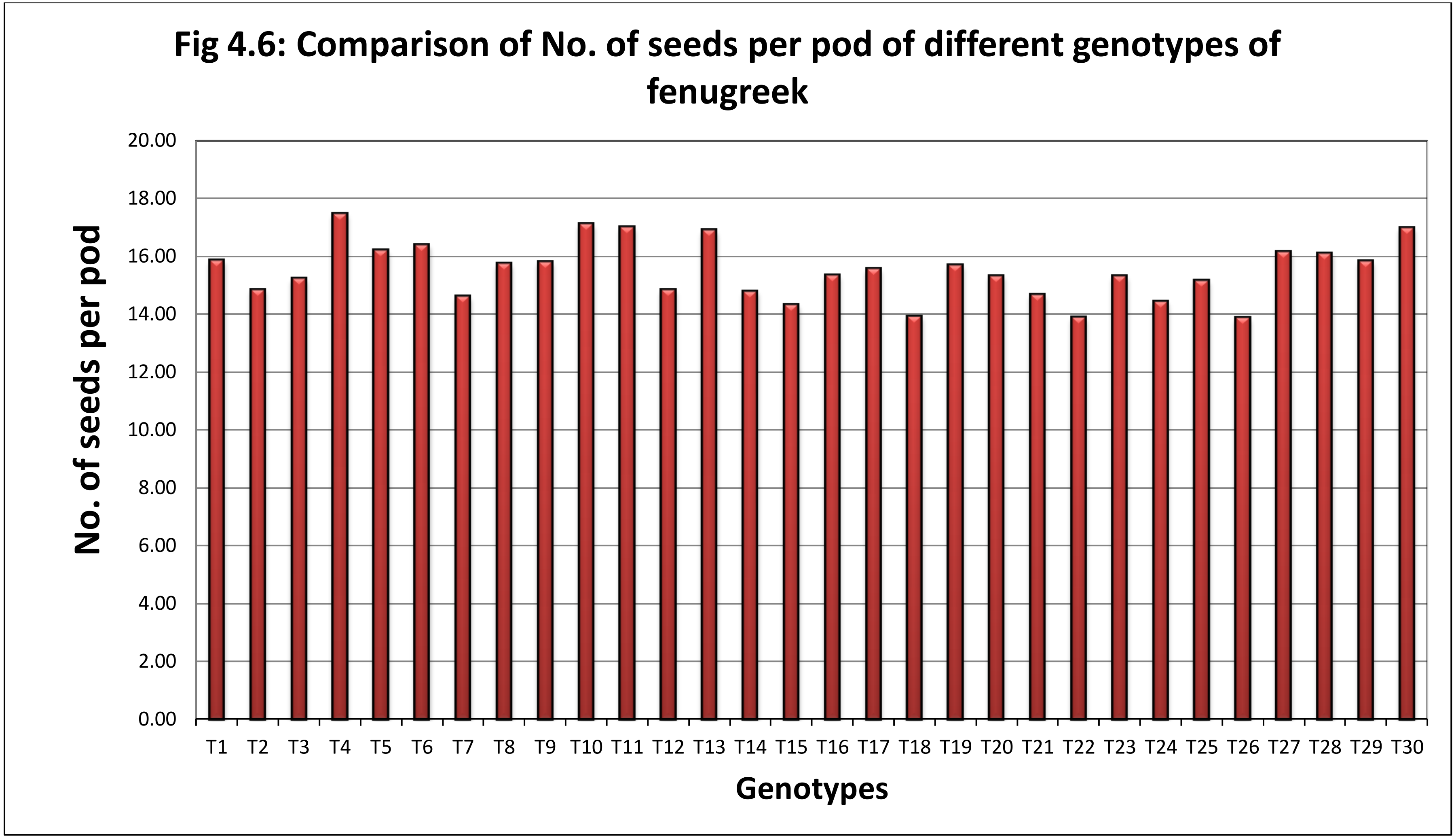


Fig 4.6: Comparison of No. of seeds per pod of different genotypes of fenugreek
No. of seeds per pod
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

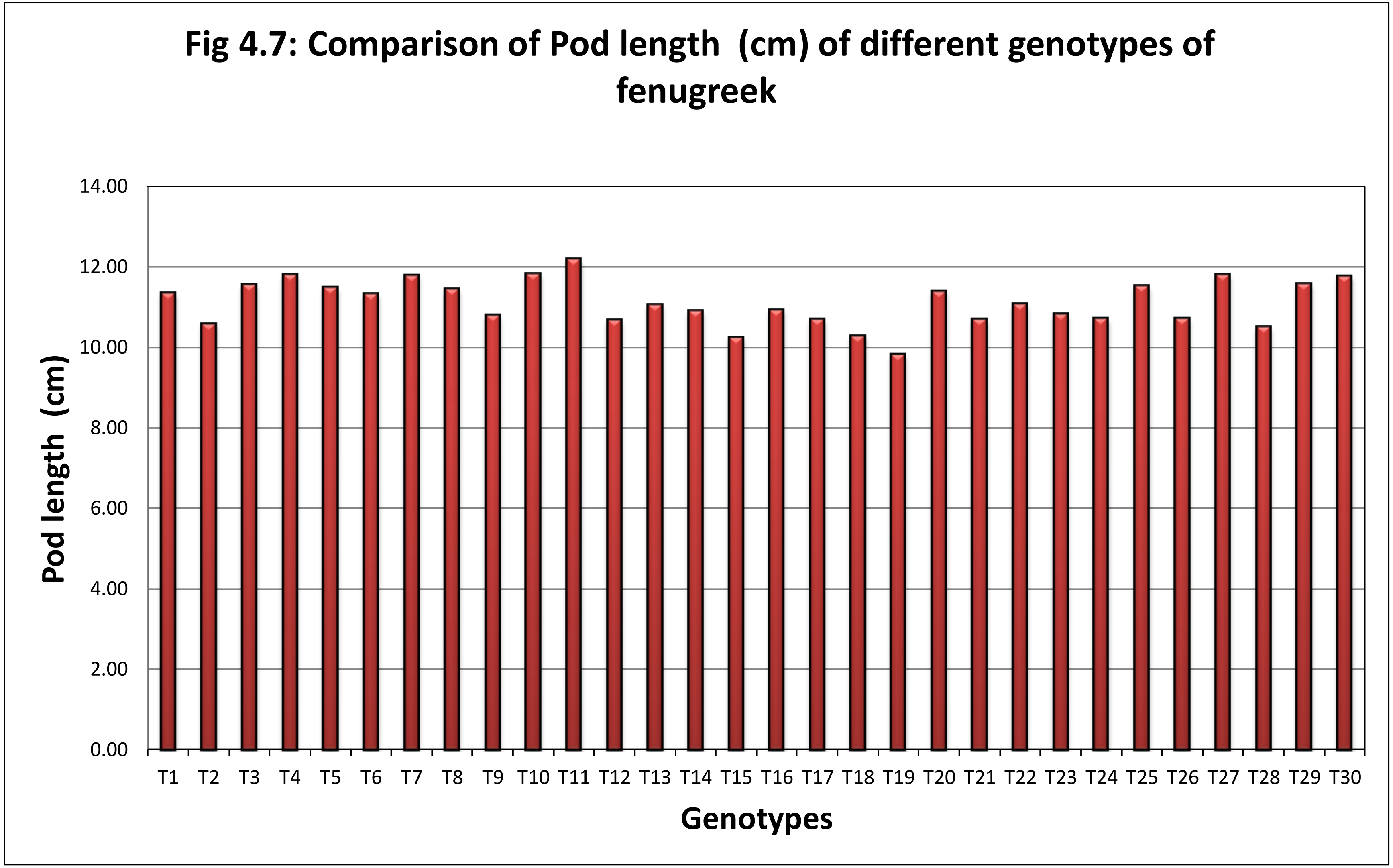


Fig 4.7: Comparison of Pod length (cm) of different genotypes of fenugreek
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Pod length (cm)
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

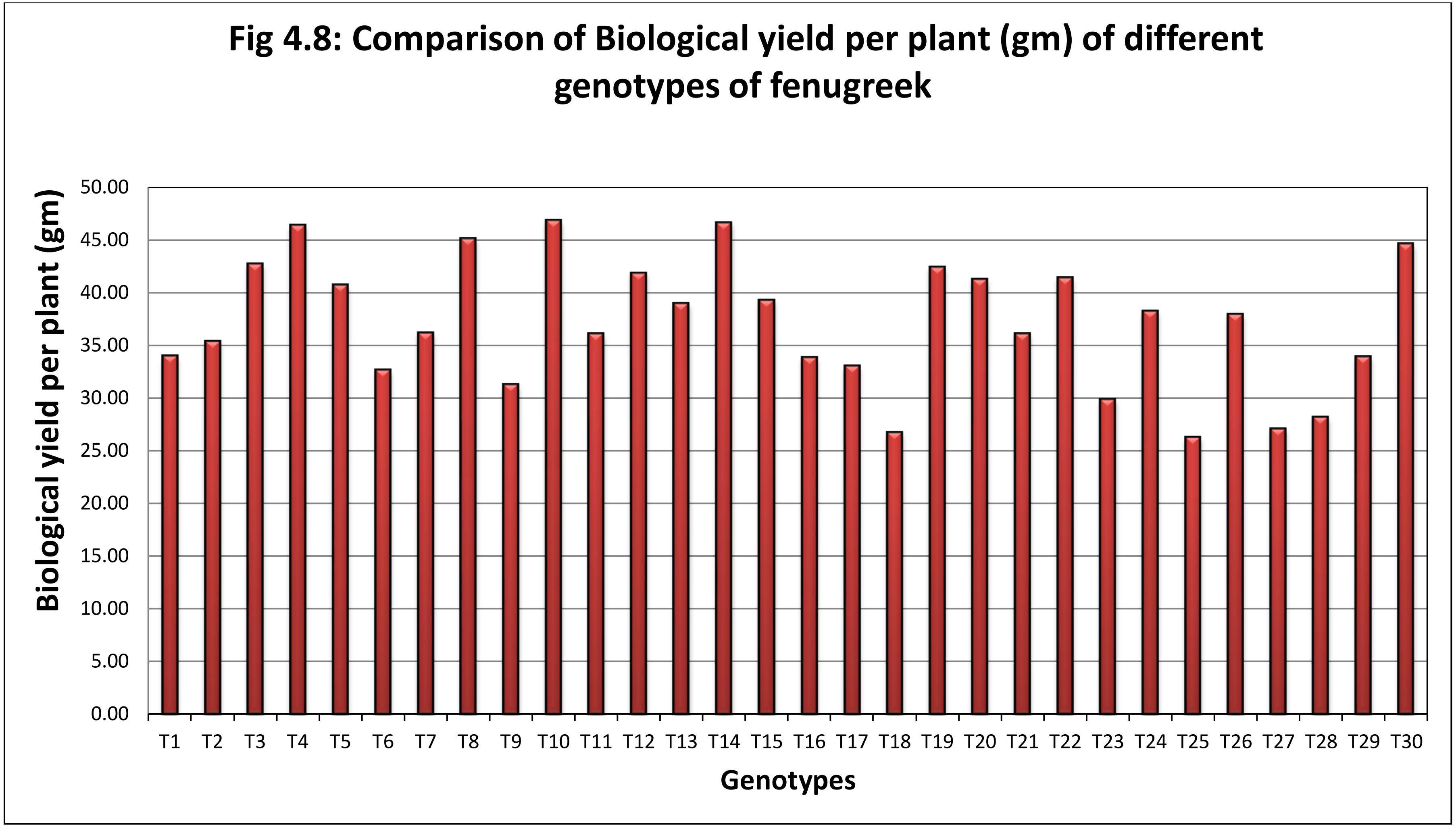


Fig 4.8: Comparison of Biological yield per plant (gm) of different genotypes of fenugreek
Biological yield per plant (gm)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

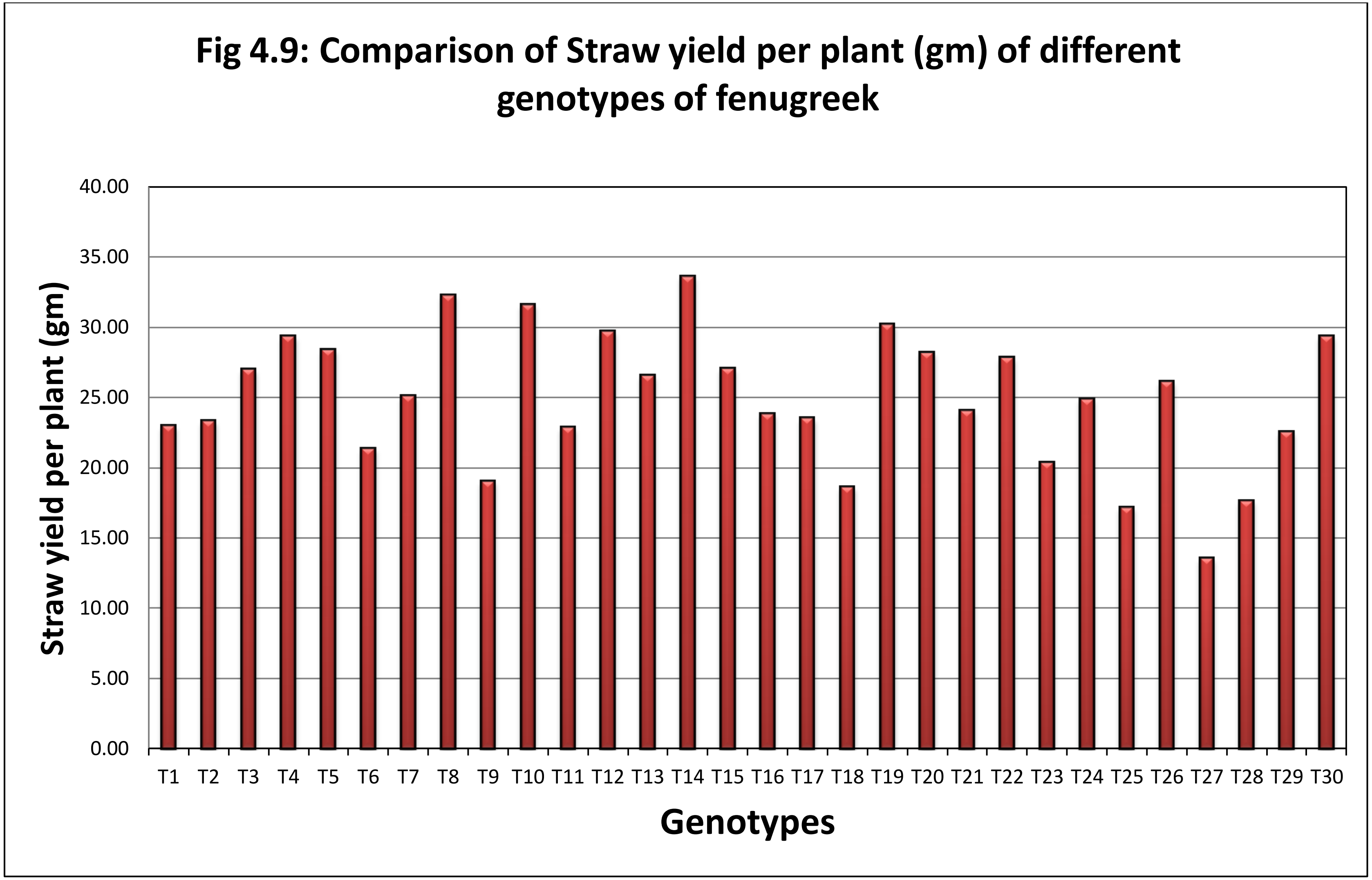


Fig 4.9: Comparison of Straw yield per plant (gm) of different genotypes of fenugreek
Straw yield per plant (gm)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

Fig 4.10: Comparison of Protein content in seed (%) of different genotypes of fenugreek

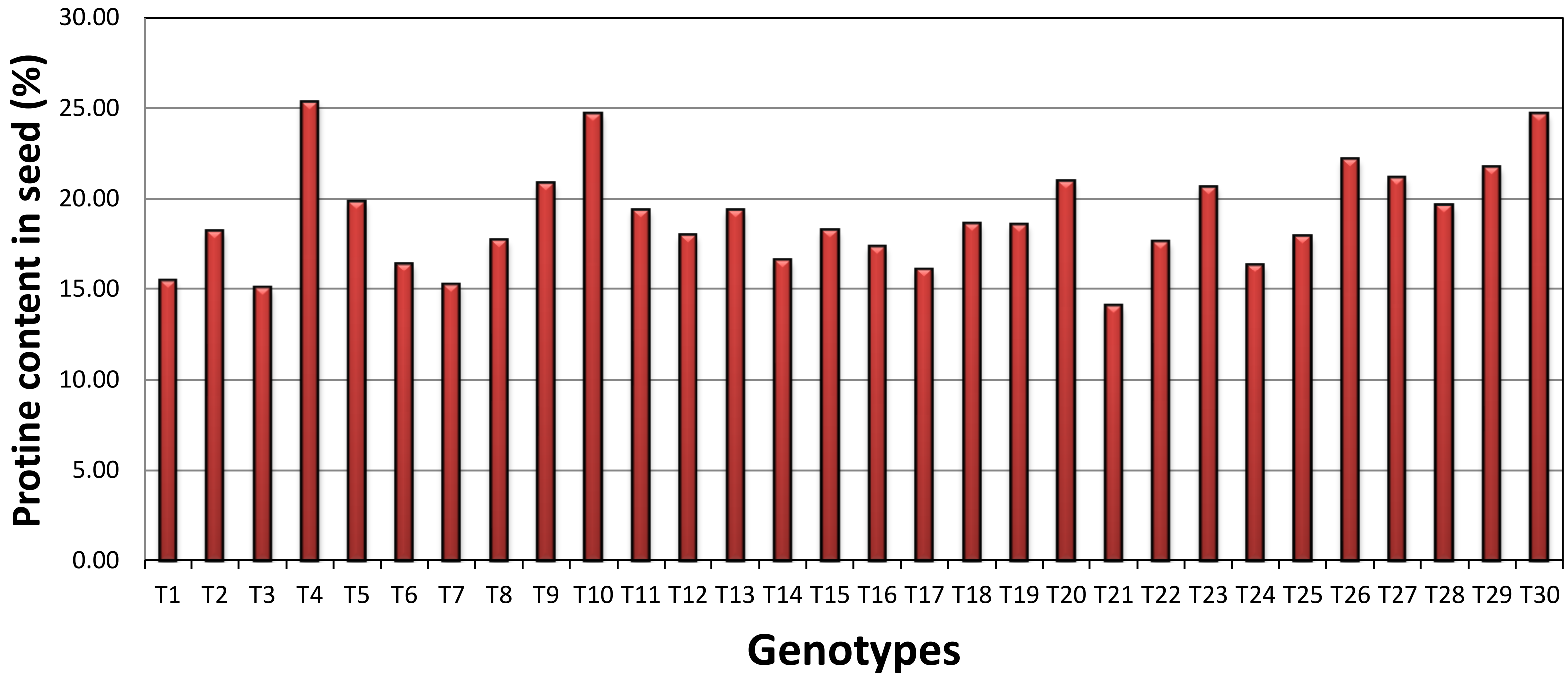
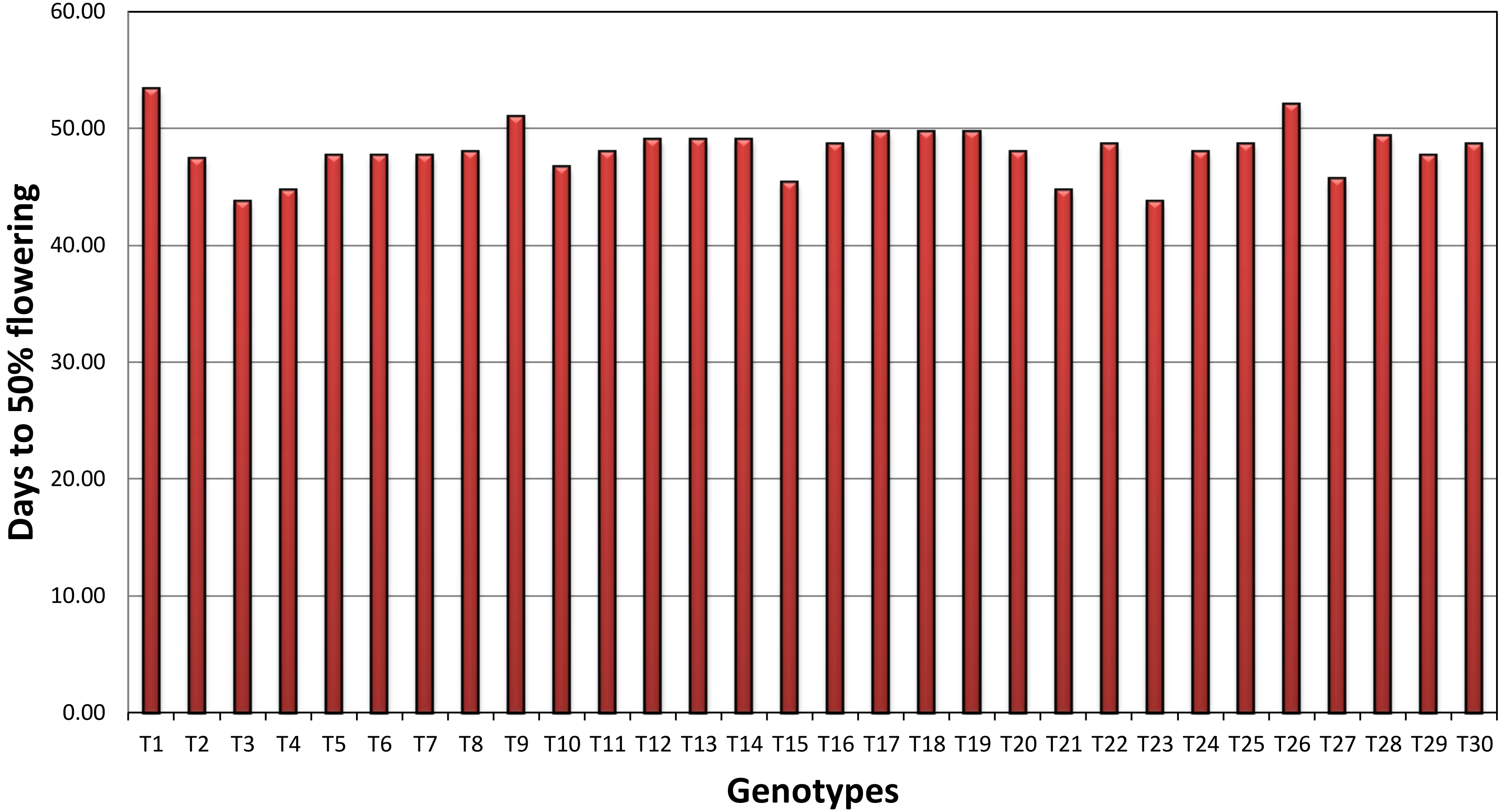


Fig 4.11: Comparison of Days to 50% flowering of different genotypes of fenugreek



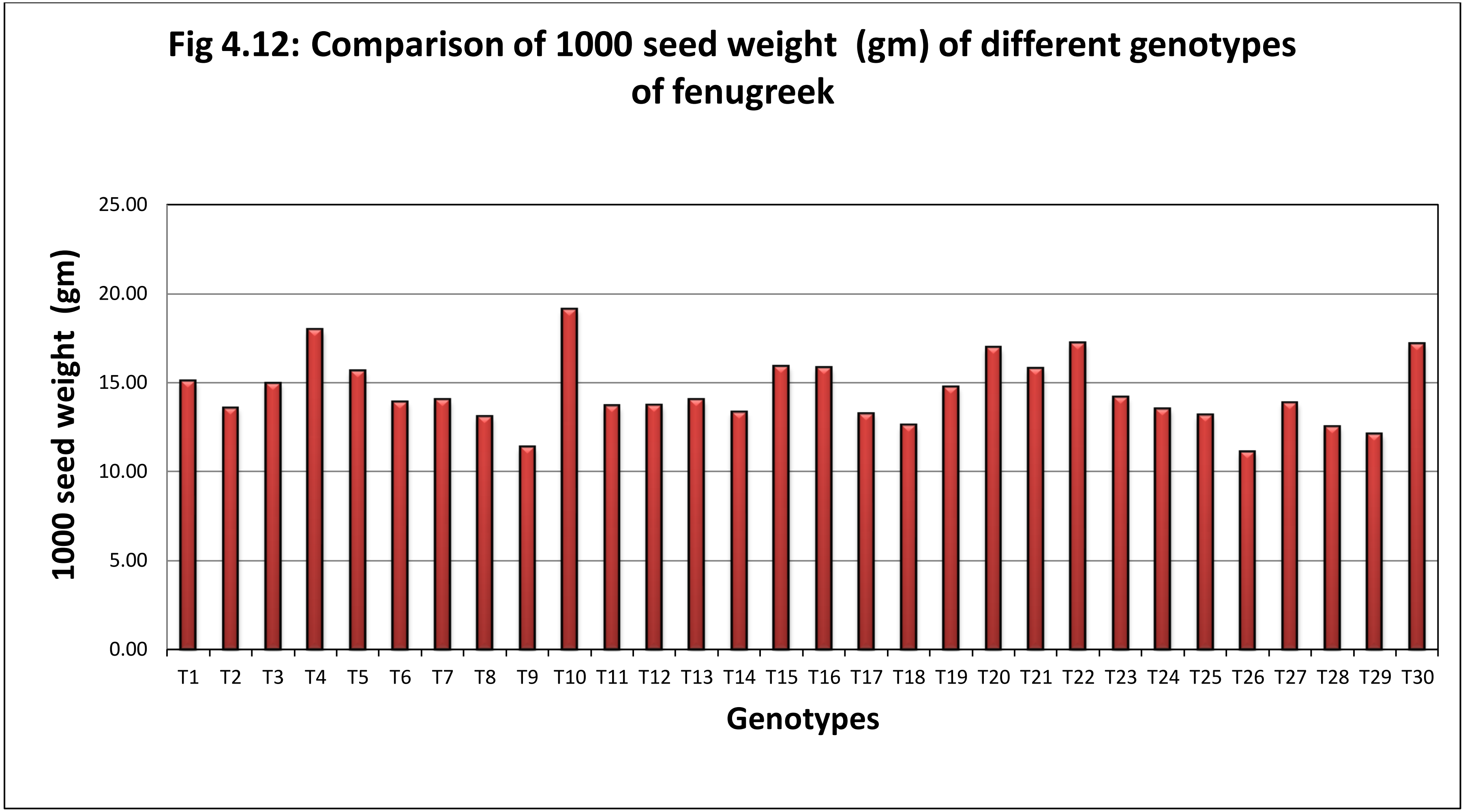
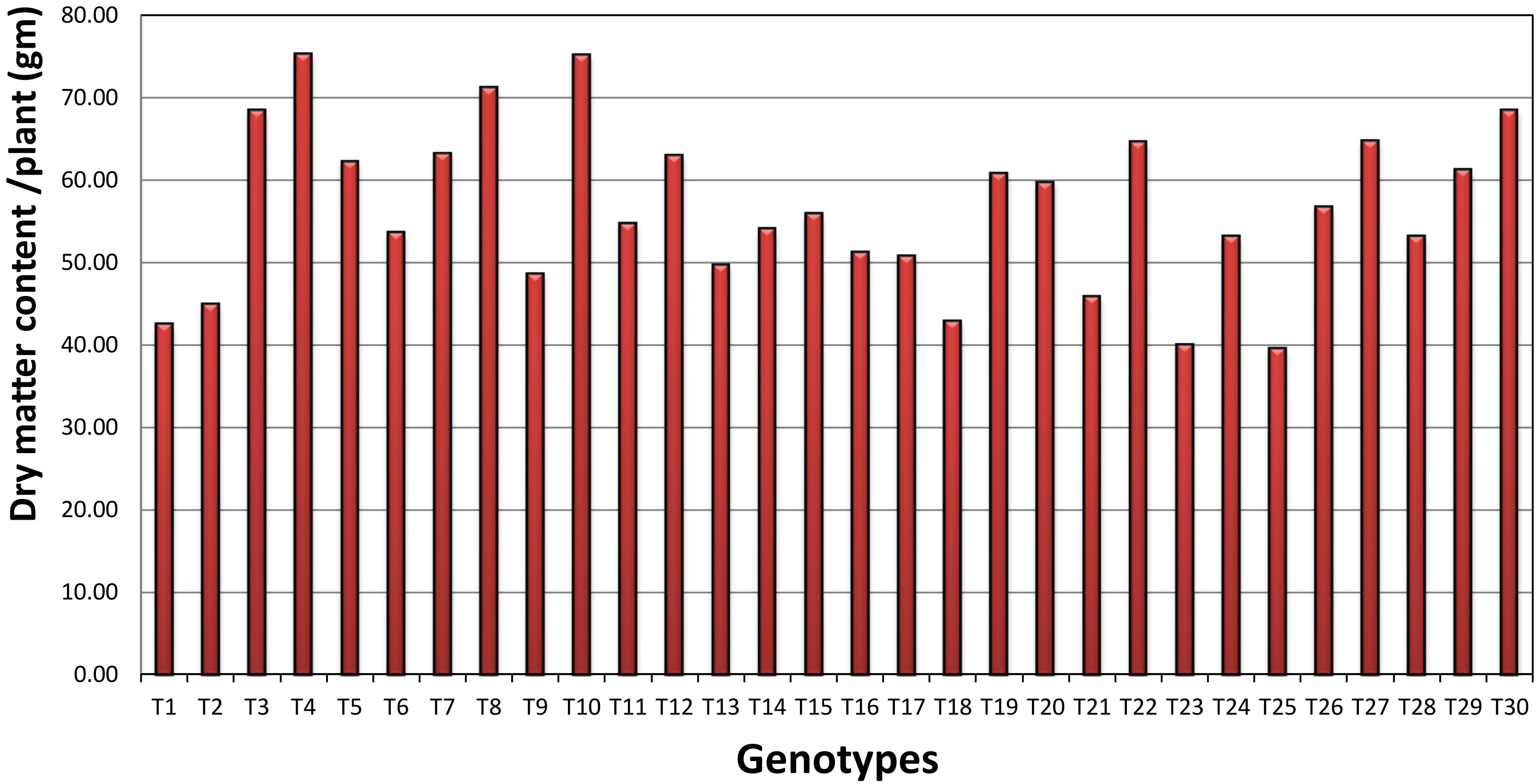


Fig 4.12: Comparison of 1000 seed weight (gm) of different genotypes of fenugreek
25.00
20.00
15.00
10.00
5.00
0.00
1000 seed weight (gm)
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16 T17 T18 T19 T20 T21 T22 T23 T24 T25 T26 T27 T28 T29 T30
Genotypes

Fig 4.13: Comparison of Dry matter content per plant (gm) of different genotypes of fenugreek



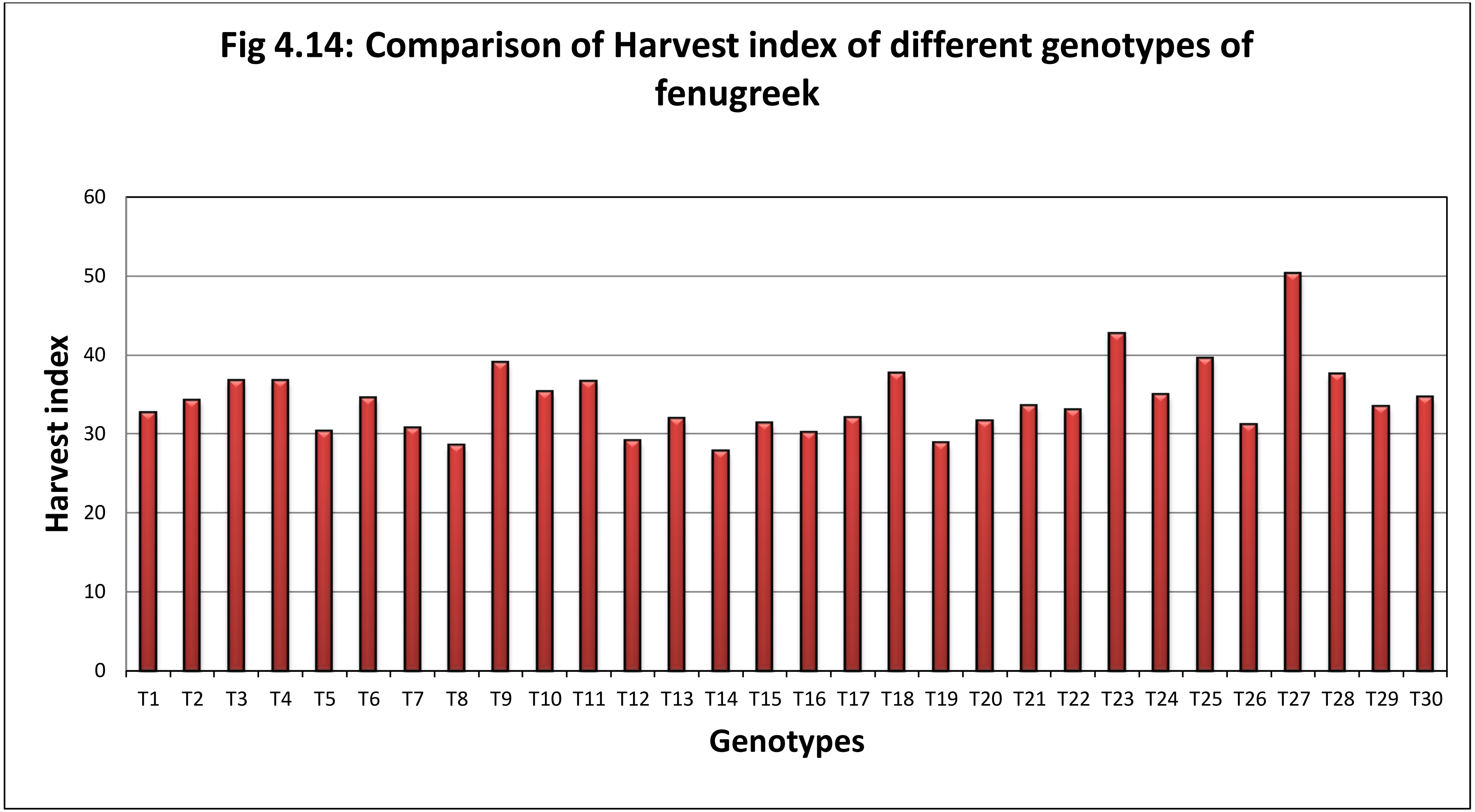
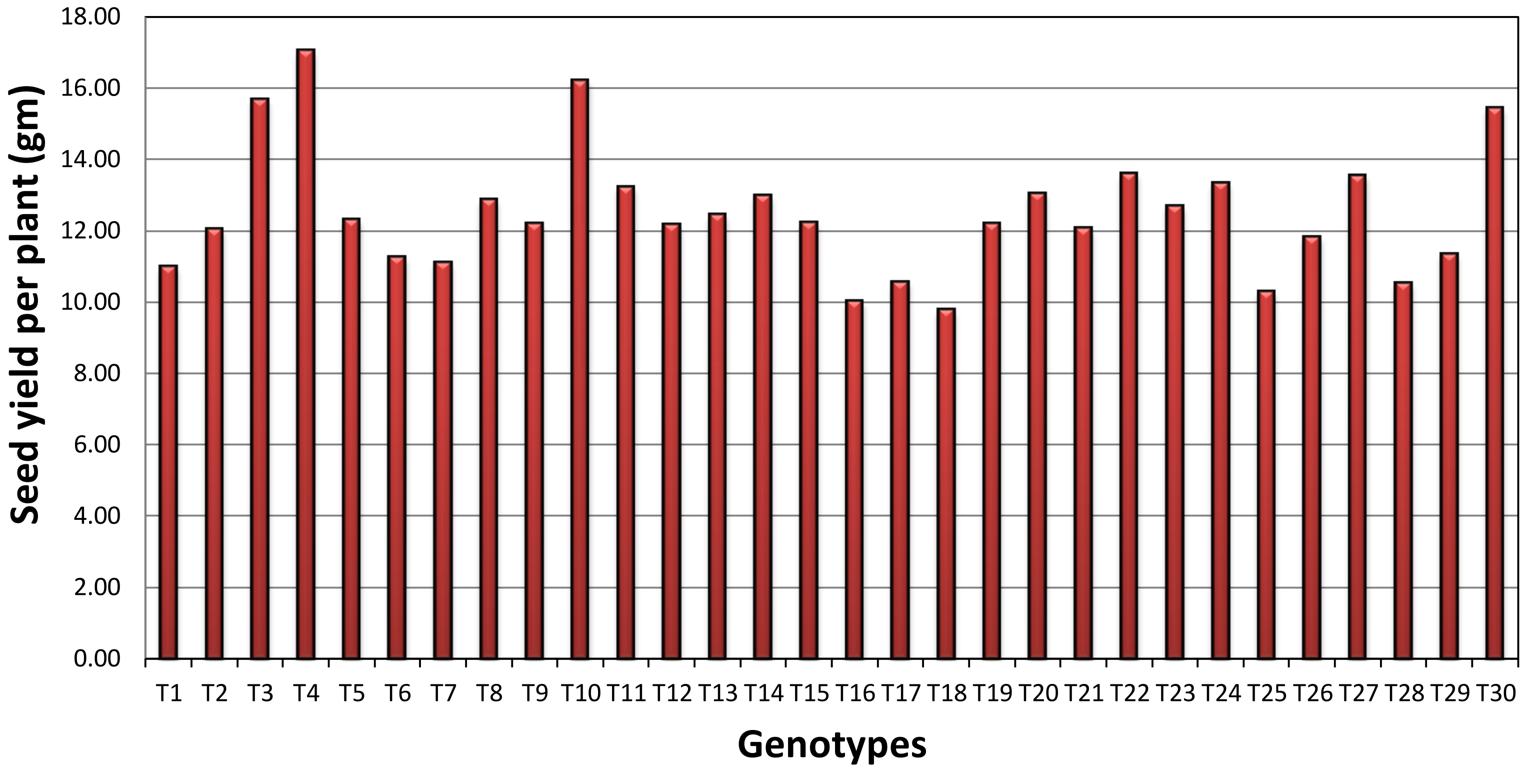


Fig 4.14: Comparison of Harvest index of different genotypes of fenugreek
Harvest index
60
50
40
30
20
10
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
T14
T15
T16
T17
T18
T19
T20
T21
T22
T23
T24
T25
T26
T27
T28
T29
T30
Genotypes

Fig 4.15: Comparison of Seed yield per plant (gm) of different genotypes of fenugreek



4.8 1000 seed weight (g): The maximum test weight of seeds was recorded in genotype UM-36 (19.10g) being significantly superior over all other genotypes, followed by RMT-143 (17.93g) and UM-351 (17.20g). The minimum test weight was found in genotype UM-35 (11.10g).

4.9 Seed yield per plant (g): The significant differences were exhibited amongst the genotype in respect of yield per plant. The genotype RMT-143 (17.03g).recorded higher yield per plant, followed by UM-36 (16.22g), AFg-2 (15.43g). The lowest seed yield (9.77g) per plant was recorded in UM-116.

4.10 Biological yield (g): The mean maximum biological yield of per plant was recorded in genotype UM-36 (46.83g) followed by UM-32 (46.60g), RMT-143(46.37g). The minimum biological yield per plant was recorded in genotype UM-2(26.20g).

4.11 Straw yield per plant (g): The mean maximum straw yield of per plant was recorded in genotype UM-32 (33.62g) followed by UM-29 (32.27g), UM-36(31.60g). The minimum straw yield per plant was recorded in genotype UM-18(13.50g).

4.12 Dry matter content (g): The mean maximum dry matter content per plant was recorded in genotype RMT-143 (75.23g) followed by UM-36(75.17g), UM-29 (71.47g). The mean minimum dry matter content of per plant was recorded in genotype UM-2 (39.53g).

4.13 Harvest index: The mean maximum harvest index of per plant was recorded in genotype UM-18 (50.24) followed by RMT-305 (42.66), UM-2(39.56). The minimum harvest index per plant was recorded in genotype UM-32(27.79).

C. QUALITY PARAMETER:

4.14 Chlorophyll content in leaves (Spad value): The mean maximum chlorophyll content in leaves was recorded in genotype AFg-2 (59.47 SPAD value) followed by UM-351 (59.23 Spad value), RMT-143 (59.20 SPAD value). The chlorophyll content in leaves was recorded in genotype RMT-303(45.47).

4.15 Protein content in seed (%): The mean maximum Protein content in seed was recorded in genotype RMT-143 (25.33%) followed by UM-36 (24.68), AFg-

2(24.67%). The minimum Protein content in seed was recorded in genotype Local-1 (14.03%).

D. VARIABILITY STUDIES:

4.16 Genotypic coefficient of variation and phenotypic coefficient of variation: The PCV was higher in its corresponding GCV for all the parameters under present study. Data pertaining to genetic parameters are presented in Table 4.2.

The highest range of PCV and GCV value was recorded for dry weight at flower initiation (22.56), followed by straw yield per plant(21.63), dry matter content per plant (19.06), biological yield (17.97), harvest index(16.16), seed yield per plant(16.02), protein content in seed(15.46), 1000 seed weight (14.08), no. of pods per plant (13.08), no. of branches per plant (10.99), plant height(9.89), no of seeds per pod (7.32), chlorophyll content in leaves(7.19), pod length (7.10), days to 50% flowering (5.19). Whereas highest GCV was recorded for dry weight at flower initiation (21.36), followed by straw yield per plant(18.23), dry matter content per plant (17.09), biological yield (15.89), protein content in seed(15.23), seed yield per plant(13.30), 1000 seed weight (12.97), no. of pods per plant (12.86), harvest index(12.32), plant height(8.74), chlorophyll content in leaves(6.71), no. of branches per plant (6.42), no of seeds per pod (5.92), days to 50% flowering (4.32) pod length (3.51),. The lowest range of PCV was recorded in days to 50% flowering (5.19) and GCV was recorded in pod length (3.51).

Table 4.2: Genetic parameter of yield and yield attributing characters in fenugreek genotypes

Character	Mean	Range		PCV%	GCV%	Heritability (BS) %	Genetic Advance	Genetic advance as percentage of mean
		Min.	Max.					
Plant height (cm)	65.91	46.20	74.83	9.89	8.74	78.2	10.50	15.93
No. of branches/plant	14.60	11.23	16.20	10.99	6.42	34.2	1.13	7.73
Dry weight at flower initiation(g)	3.86	2.23	5.27	22.56	21.36	89.7	1.61	14.70
Chlorophyll content in leaves (SPAD Unit)	54.11	45.47	59.47	7.19	6.71	87.1	6.98	12.89
No. of pods/plant	66.74	51.10	80.14	13.08	12.86	96.7	17.39	26.05
No. of seeds / pod	15.50	13.86	17.47	7.32	5.92	65.4	1.53	9.87
Pod length (cm)	11.12	9.82	12.19	7.10	3.51	24.4	0.40	3.59
Biological yield/plant (g)	37.13	26.20	46.83	17.97	15.89	78.2	10.75	28.95
Straw yield per plant (gm)	24.92	13.50	33.62	21.63	18.23	71.0	7.89	31.66
Protein content in seed (%)	18.91	14.03	25.53	15.46	15.23	96.9	5.84	30.88
Days to 50% flowering	48.41	43.67	53.33	5.19	4.32	69.4	3.56	7.35
1000 seed wt (g)	14.41	11.10	19.10	14.08	12.97	84.8	3.55	24.63
Dry matter content (g)	56.48	39.53	75.23	19.06	17.09	80.4	17.83	31.56
Harvest index	34.19	27.89	50.24	16.16	12.32	58.1	6.62	19.36
Seed yield /plant(g)	12.49	9.77	17.03	16.02	13.30	68.9	2.84	22.73

4.17 Heritability: Estimates with regard to heritability (broad sense) have been presented in Table 4.2. Heritability estimates varied from parameter to parameter and also with the change in environment for the same parameters. Therefore heritability estimates in broad sense were classified in to three groups. High more than 70, medium 50 to 70 and low less than 50.

Heritability estimates in broad sense were high for protein content in seed(96.9), followed by no. of pods per plant (96.7), dry weight at flower initiation (89.7), chlorophyll content in leaves(87.10), 1000 seed weight (84.8), dry matter content (80.4), biological yield per plant (78.2), plant height (78.2),straw yield per plant(71.0), days to 50% flowering (69.4), seed yield per plant (68.9), no. of seeds per pod (65.4), harvest index (58.1), no. of branches (34.2), pod length (24.4).

4.18 Genetic advance: High range of genetic advance was recorded for dry matter content (17.83), followed by no. of pods per plant (17.39), biological yield (10.75), plant height (10.50), straw yield per plant (7.89), chlorophyll content in leaves(6.98), harvest index(6.62), protein content in seed(5.84), days to 50% flowering (3.56), 1000 seed weight (3.55), seed yield per plant (2.84), dry weight at flower initiation (1.61), no. of seeds per pod (1.53), no. of branches per plant (1.13) and pod length (0.40).

4.19 Genetic advance as percentage mean: The units of Measurement the magnitude of genetic advance. Therefore ton avoids this and to facilitate the comparison of genetic improvement in various parameters, genetic advance was computed as percentage as mean of the parameter over environment. It has been classified as high (more than 30), medium (20 to 30) and low (less than 20).

High range of genetic advance as percentage of mean was recorded for straw yield per plant(31.66%), followed by dry matter content (31.56%), protein content in seed(30.88%), biological yield (28.95%), no. of pods per plant (26.05%), 1000 seed weight (24.63%), seed yield per plant (22.73%), harvest index (19.36%), plant height (15.93%), dry weight at flower initiation (14.70%), chlorophyll content in leaves(12.89%), no. of seeds per pod (9.87%), no. of branches per plant (7.73%), days to 50% flowering (7.35%) and pod length (3.59%).

D. Correlation coefficient analysis:- Correlation studies provide information regarding any two parameters, which are under consideration whether the increase in one variable causes either increase or decrease in other variable. There by, definite relationships ascertain their interdependence.

The correlation coefficients among different characters were worked out in all possible of growth and yield parameters with seed yield per plant (g) at phenotypic and genotypic level.

(a) Genotypic correlation coefficients:-The results obtained are presented in Table 4.3.

Genotypic correlations were generally higher than phenotypic.

1. Plant height (cm): At genotypic level the plant height had highly significant positive correlation with 1000 seed weight (0.683), pod length (0.607), dry matter content (0.588), biological yield (0.430), seed yield per plant (0.413), chlorophyll content in leaves(0.413), straw yield per plant (0.337), but positive correlation with no. of pods per plant (0.286), dry weight at flower initiation (0.283), no. of seeds per pod (0.196), protein content in seed(0.101), while it was negative with No. of branches (-0.049), days to 50% flowering (-0.150) and harvest index(-0.177).

2. Number of branches per plant: No. of branches had significant positive correlation with protein content in seed (0.653), chlorophyll content in leaves (0.594), no. of pods per plant (0.592), seed yield per plant (0.515), 1000 seed weight (0.509), biological yield per plant (0.456), straw yield per plant(0.449), but positive correlation with no. of seeds per pod (0.272), dry matter content (0.160), while it was negative with pod Length (-0.052), harvest index (-0.060), dry weight at flower initiation (-0.153) and days to 50% flowering (-0.247).

Table 4.3: Genotypic correlation coefficient of yield and its component characters of fenugreek

Characters	**Plant height (cm)**	**No. of branches/ plant**	**Dry wt at flower initiation (g)**	**Chlorophyll content (SPAD Unit)**	**No. of pods/ plant**	**No. of seeds/ Pod**	**Pod length (cm)**	**Biological yield/plant(g)**	**Straw yield/ plant (g)**	**Protein content in seed (%)**	**Days to 50% flowering**	**1000 seed wt (g)**	**Dry matter content (g)**	**Harvest index**	**Seed yield /plant (g)**
Plant height (cm)		**-0.049**	0.283	0.413*	0.286	0.196	0.607**	0.430*	0.337*	0.101	-0.150	0.683**	0.588**	-0.177	0.413*
No. of branches/ plant			**-0.153**	0.594**	0.592**	0.272	-0.052	0.456**	0.449**	0.653**	-0.247	0.509**	0.160	-0.060	0.515**
Dry wt at flo. initiation (g)				**0.069**	0.240	0.482**	0.580**	0.200	0.161	0.241	0.017	0.300	0.253	-0.008	0.288
Chlorophyll (SPAD Unit)					**0.380***	-0.147	0.031	0.518**	0.527**	0.181	-0.106	0.581**	0.207	-0.293	0.420*
No. of pods/plant						**0.321**	0.161	0.850**	0.826**	0.318	-0.169	0.375*	0.538**	-0.428*	0.680**
No. of seeds/pod							**0.773****	0.215	0.089	0.567**	-0.086	0.386*	0.400*	0.226	0.483**
Pod length (cm)								**0.248**	0.056	0.445**	-0.300	0.462**	0.674**	0.356*	0.646**
Biological yield/p (g)									**0.969****	0.213	-0.167	0.609**	0.749**	-0.607**	0.741**
Straw yield per plant (gm)										**0.096**	-0.041	0.532**	0.632**	-0.755**	0.575**
Protein content in seed (%)											**-0.073**	0.275	0.448**	0.329	0.550**
Days to 50% flowering												**-0.433****	-0.314	-0.411*	-0.572**
1000 seed wt (g)													**0.522****	-0.105	0.690**
Dry matter content (g)														**-0.193**	0.759**
Harvest index															**0.073**
Seed yield /plant(g)															

**1% level of significance * 5% level of significance

3. Dry weight of plant at flower initiation (g): The dry weight at flower initiation had highly significant positive correlation with pod length (0.580), no. of seeds per pod (0.482), but positive correlation with 1000 seed weight (0.300), seed yield per plant (0.288), dry matter content (0.253), protein content in seed (0.241), no. of pods per plant (0.240), biological yield (0.200), straw yield per plant(0.161), chlorophyll content in leaves(0.069), days to 50% flowering (0.017) while it was negative with harvest index(-0.008).

4. Chlorophyll content in leaves: The chlorophyll content in leaves had highly significant positive correlation with 1000 seed weight (0.581), straw yield per plant (0.527), biological yield (0.518), seed yield per plant (0.420), no. of pods per plant (0.380) but positive correlation with dry matter content (0.207), protein content in seed (0.181), pod length (0.031), while it was negative with days to 50% flowering (-0.106), no. of seeds per pod (-0.147) and harvest index (-0.293).

5. No. of pods per plant: At genotypic level it had highly significant positive correlation with biological yield (0.850), straw yield per plant (0.826), seed yield per plant (0.680), dry matter content (0.538), 1000 seed weight (0.375) but positive correlation with no. of pods per plant (0.321), protein content in seed (0.318), pod length (0.161) while negative correlation with days to 50% flowering (-0.169), and harvest index (-0.428).

6. No. of seeds per pod: The no. of seeds per pod had highly significant positive correlation with pod length (0.773), protein content in seed (0.567), seed yield per plant (0.483), dry matter content (0.400) 1000 seed weight (0.386) but positive correlation with harvest index (0.226), biological yield (0.215) and straw yield per plant (0.089) while negative correlation with days to 50% flowering (-0.086).

7. Pod length (cm): The pod length had positive correlation with dry matter content (0.674), seed yield per plant (0.646), 1000 seed weight (0.462), protein content in seed (0.445), harvest index (0.356) but positive correlation with biological yield (0.248), straw yield per plant (0.056) while negative correlation with days to 50% flowering (-0.300).

8. Biological yield per plant (g): The biological yield had highly significant positive correlation with straw yield per plant (0.969), dry matter content (0.749), seed yield per plant (0.741), 1000 seed weight (0.609) but positive correlation with protein content in seed (0.213) while negative correlation with days to 50% flowering (-0.167) and harvest index (-0.607).

9. Straw yield per plant (g): The straw yield per plant had highly significant positive correlation with dry matter content (0.632), seed yield per plant (0.575), 1000 seed weight (0.532) but positive correlation with protein content in seed (0.096) while negative correlation with days to 50% flowering (-0.041) and harvest index (-0.755).

10. Protein content in seed (%): The protein content had highly significant positive correlation with seed yield per plant (0.550), dry matter content (0.448) but positive correlation with harvest index (0.329), 1000 seed weight (0.275) while negative correlation with days to 50% flowering (-0.073).

11. Days to 50 % flowering: The Days to 50% flowering negative correlation with dry matter content (-0.314), harvest index (-0.441), 1000 seed weight (-0.433) and seed yield per plant (-0.572.

12. 1000 seed weight (g): The 1000 seed weight had highly significant positive correlation with seed yield per plant (0.690) and dry matter content (0.522) while negative correlation with harvest index (-0.105).

13. Dry matter content (g): The dry matter content had highly significant positive correlation with seed yield per plant (0.759) while negative correlation with harvest index (-0.193).

14. Harvest index: The harvest index significant positive correlation with seed yield per plant (0.073).

15. Seed yield per plant (g): The seed yield per plant had highly significant positive correlation with dry matter content (0.759), biological yield (0.741), 1000 seed weight (0.690), no. of pods per plant (0.680), pod length (0.646), straw yield per plant (0.575), protein content in seed (0.550), no. of branches (0.515), no. of seeds per pod (0.483), chlorophyll content in leaves (0.420), plant height (0.413), dry weight at flower initiation (0.288), but it was positively non- significantly correlated with harvest index (0.073) while negative correlation with while negative correlation with days to 50% flowering (-0.572).

(b) Phenotypic correlation coefficients:- The results obtained are presented in Table 4.4.

1. Plant height (cm): At phenotypic level the plant height had highly significant positive correlation with 1000 seed weight (0.558), dry matter content (0.486), chlorophyll content in leaves(0.341) but positive correlation with biological yield (0.326), seed yield per plant (0.295), pod length (0.270), no. of pods per plant (0.235), dry weight at flower initiation (0.219), straw yield per plant (0.217), no. of seeds per pod (0.123), protein content in seed(0.097), No. of branches (0.011), while it was negative with days to 50% flowering (-0.093) and harvest index(-0.108).

2. Number of branches per plant: No. of branches had significant positive correlation with seed yield per plant (0.401), protein content in seed (0.379), no. of pods per plant (0.355) but positive correlation with biological yield per plant(0.285), 1000 seed weight (0.268), chlorophyll content in leaves (0.265), straw yield per plant(0.207), dry matter content (0.184), harvest index(0.032), no. of seeds per pod (0.030) while it was negative with days to 50% flowering (-0.023) pod length (-0.046) and dry weight at flower initiation (-0.077).

3. Dry weight of plant at flower initiation (g): The dry weight at flower initiation had highly significant positive correlation with no. of seeds per pod (0.407) but positive correlation with pod length (0.310), seed yield per plant (0.258), 1000 seed weight (0.252), protein content in seed (0.224), no. of pods per plant (0.220), dry matter content (0.207), biological yield (0.162), straw yield per plant(0.118), chlorophyll content in leaves(0.063), harvest index(0.031) and days to 50% flowering (0.027).

4. Chlorophyll content in leaves: The chlorophyll content in leaves had highly significant positive correlation with 1000 seed weight (0.512), biological yield (0.419), straw yield per plant (0.411), no. of pods per plant

(0.351) but positive correlation with seed yield per plant (0.289), dry matter content (0.192), protein content in seed (0.167) while it was negative with harvest index (-0.039), days to 50% flowering (-0.047), pod length (-0.049) and no. of seeds per pod (-0.106).

5. No. of pods per plant: At phenotypic level it had highly significant positive correlation with biological yield (0.770), straw yield per plant (0.713), seed yield per plant (0.560), dry matter content (0.487), 1000 seed weight (0.351) but positive correlation with protein content in seed (0.310), no. of pods per plant (0.196), pod length (0.071) while negative correlation with days to 50% flowering (-0.152), and harvest index (-0.356).

6. No. of seeds per pod: The no. of seeds per pod had highly significant positive correlation with protein content in seed (0.455), pod length (0.390) seed yield per plant (0.371) but positive correlation with dry matter content (0.279), 1000 seed weight (0.223), harvest index (0.196), biological yield (0.128) and straw yield per plant (0.006) while negative correlation with days to 50% flowering (-0.169).

7. Pod length (cm): The pod length had positive correlation with seed yield per plant (0.304) but positive correlation with dry matter content (0.272), harvest index (0.231), protein content in seed (0.211), 1000 seed weight (0.167), biological yield (0.063) while negative correlation with straw yield per plant (-0.035) and days to 50% flowering (-0.171).

Table 4.4: Phenotypic correlation coefficient of yield and its component characters of fenugreek

Characters	Plant height (cm)	No. of branches/ plant	Dry wt. at flower initiation (g)	Chlorophyll (SPAD Unit)	No. of pods/ plant	No. of seeds/ Pod	Pod length (cm)	Biological yield/plant(g)	Straw yield per plant (gm)	Protein content in seed (%)	Days to 50% flowering	1000 seed wt (g)	Dry matter content (g)	Harvest index	Seed yield /plant (g)
Plant height (cm)		**0.011**	0.219	0.341*	0.235	0.123	0.270	0.326	0.217	0.097	-0.093	0.558**	0.486**	-0.108	0.297
No. of branches/ plant			**-0.077**	0.265	0.355*	0.030	-0.046	0.285	0.207	0.379*	-0.023	0.268	0.184	0.032	0.401*
Dry wt at flo. initiation (g)				**0.063**	0.220	0.407*	0.310	0.162	0.118	0.224	0.027	0.252	0.207	0.031	0.258
Chlorophyll (SPAD Unit)					**0.351***	-0.106	-0.049	0.419*	0.411*	0.167	-0.047	0.512**	0.192	-0.039	0.289
No. of pods/plant						**0.196**	0.071	0.770**	0.713**	0.310	-0.152	0.351*	0.487**	-0.356*	0.560**
No. of seeds/pod							**0.390***	0.128	0.006	0.455**	-0.169	0.223	0.279	0.196	0.371*
Pod length (cm)								**0.063**	-0.035	0.211	-0.171	0.167	0.272	0.231	0.304
Biological yield/p (g)									**0.953****	0.189	-0.106	0.479**	0.634**	-0.573**	0.623**
Straw yield per plant (gm)										**0.086**	-0.022	0.398*	0.494**	-0.750**	0.385*
Protein content in seed (%)											**-0.051**	0.254	0.399*	0.232	0.437**
Days to 50% flowering												**-0.353***	-0.218	-0.265	-0.375*
1000 seed wt (g)													**0.419***	-0.096	0.498**
Dry matter content (g)														**-0.013**	0.639**
Harvest index															**0.263**
Seed yield /plant(g)															

** 1% level of significance * 5% level of significance

8. Biological yield per plant (g): The biological yield had highly significant positive correlation with straw yield per plant (0.953), dry matter content (0.634), seed yield per plant (0.623), 1000 seed weight (0.479) but positive correlation with protein content in seed (0.189) while negative correlation with days to 50% flowering (-0.106) and harvest index (-0.573).

9. Straw yield per plant (g): The straw yield per plant had highly significant positive correlation with dry matter content (0.494), 1000 seed weight (0.398), seed yield per plant (0.385) but positive correlation with protein content in seed (0.086) while negative correlation with days to 50% flowering (-0.022) and harvest index (-0.750).

10. Protein content in seed (%): The protein content had highly significant positive correlation with seed yield per plant (0.437), dry matter content (0.399) but positive correlation with 1000 seed weight (0.254), harvest index (0.232), while negative correlation with days to 50% flowering (-0.051).

11. Days to 50 % flowering: The Days to 50% flowering negative correlation with dry matter content (-0.218), harvest index (-0.265), 1000 seed weight (-0.353) and seed yield per plant (-0.375).

12. 1000 seed weight (g): The 1000 seed weight had highly significant positive correlation with seed yield per plant (0.498) and dry matter content (0.419) while negative correlation with harvest index (-0.096).

13. Dry matter content (g): The dry matter content had highly significant positive correlation with seed yield per plant (0.639) while negative correlation with harvest index (-0.013).

14. Harvest index: The harvest index significant positive correlation with seed yield per plant (0.263).

15. Seed yield per plant (g): The seed yield per plant had highly significant positive correlation with dry matter content (0.639), biological yield (0.623), no. of pods per plant (0.560), 1000 seed weight (0.498), protein content in seed (0.437), no. of branches (0.401), straw yield per plant (0.385), no. of seeds per pod (0.371), but it was positively non significantly correlated with pod length (0.304), plant height (0.297), chlorophyll content in leaves (0.289), harvest index (0.263), dry weight at flower initiation (0.258) while negative correlation with while negative correlation with days to 50% flowering (-0.375).

E. Path coefficient

A path coefficient is a standardized partial regression coefficient and as such measures the direct influence of one variable upon another and permits partitioning of the correlation coefficients into components of direct and indirect effects. The phenotypic and genotypic correlation coefficients were further partitioned into direct and indirect effects.

Genotypic path coefficient

Direct and Indirect effects: The results are presented in Table 4.5.

1. Plant height: Plant height (-0.059) indicated negative direct effect on seed yield per plant, while it expressed indirect negative effect via protein content in seed (-0.006), harvest index (-0.088), pod length (-0.145), straw yield per plant (-0.366), However, positive indirect correlation via biological yield (0.792), chlorophyll content in leaves (0.173), dry matter content (0.166), no. of seeds per pod (0.033), dry weight at flower initiation (0.032), days to 50% flowering (0.013), no. of pods per plant (0.012), 1000 seed weight (0.007), and no. of branches (0.000).

2. Number of branches per plant: No. of branches per plant (0.000) showed positive direct effect on seed yield per plant, while it expressed indirect positive effect via biological yield (0.839), chlorophyll content in leaves (0.103), no. of seeds per pod (0.046), dry weight at flower initiation (0.032), no. of pods per plant (0.026), days to 50% flowering (0.021), pod length (0.012) 1000 seed weight (0.006) and plant height (0.003). However, the negative indirect effect of this trait were high via dry weight at flower initiation (-0.017), harvest index (-0.030), protein content in seed (-0.036) and straw yield per plant (-0.489).

Table 4.5: Genotypic path coefficient of yield and its component characters of fenugreek

Characters	Plant height (cm)	No. of branches/ plant	Dry wt. at flower initiation (g)	Chlorophyll (SPAD Unit)	No. of pods/ plant	No. of seeds/ Pod	Pod length (cm)	Biological yield/plant(g)	Straw yield per plant (g)	Protein content in seed (%)	Days to 50% flowering	1000 seed wt (g)	Dry matter content (g)	Harvest index
Plant height (cm)	**-0.059**	0.000	0.032	0.173	0.012	0.033	-0.145	0.792**	-0.366*	-0.006	0.013	0.007	0.166	-0.088
No. of branches/ plant	0.003	**0.000**	-0.017	0.103	0.026	0.046	0. 012	0.839**	-0.489**	-0.036	0.021	0.006	0.032	-0.030
Dry wt. at flo. initiation (g)	-0.017	0.000	**0.112**	0.012	0.010	0.082	-0.139	0.367*	-0.175	-0.013	0.001	0.003	0.050	-0.004
Chlorophyll (SPAD Unit)	-0.024	0.000	0.008	**0.173**	0.016	-0.025	-0.007	0.954**	-0.574**	-0.010	-0.009	0.006	0.041	-0.146
No. of pods/plant	-0.017	0.000	0.027	0.066	**0.043**	0.039	-0.039	1.566**	-0.900**	-0.017	0.014	0.004	0.106	-0.213
No. of seeds/pod	-0.011	0.000	0.054	-0.025	0.010	**0.171**	-0.185	0.395*	-0.096	-0.031	0.007	0.004	0.079	0.112
Pod length (cm)	-0.036	0.000	0.065	0.005	0.007	0.132	**-0.239**	0.456**	-0.061	-0.024	0.025	0.005	0.133	0.177
Biological yield/p (g)	-0.025	0.000	0.022	0.090	0.337*	0.037	-0.059	**1.841****	-1.055**	-0.012	0.014	0.007	0.148	-0.302
Straw yield per plant (gm)	-0.020	0.000	0.018	0.091	0.036	0.015	-0.013	1.785**	**-1.089****	-0.005	0.003	0.006	0.125	-0.376*
Protein content in seed (%)	-0.006	0.000	0.027	0.031	0.014	0.097	-0.106	0.392*	-0.104	**-0.055**	0.006	0.003	0.088	0.164
Days to 50% flowering	0.009	0.000	0.002	-0.018	-0.007	-0.015	0.072	-0.308	0.044	0.004	**-0.084**	-0.005	-0.062	-0.205
1000 seed wt (g)	-0.040	0.000	0.034	0.101	0.016	0.066	-0.111	1.121**	-0.579**	-0.015	0.036	**0.011**	0.103	-0.052
Dry matter content (g)	-0.034	0.000	0.028	0.036	0.026	0.068	-0.161	1.379**	-0.688**	-0.024	0.026	0.006	**0.197**	-0.096
Harvest index	0.010	0.000	-0.001	-0.051	-0.018	0.039	-0.085	-1.117**	0.822**	-0.018	0.034	-0.001	-0.038	**0.498****

** 1% level of significance * 5% level of significance

3. Dry weight of plant at flower initiation: dry weight at flower initiation (0.112) showed positive direct effect on seed yield per plant, while it expressed indirect positive effect via biological yield (0.367), no. of seeds per pod (0.082), dry matter content (0.050), chlorophyll content in leaves (0.012), no. of pods per plant (0.010), 1000 seed weight (0.003) and Days to 50% flowering (0.001), no. of branch per plant (0.000). However, the negative indirect effect of this trait was high via harvest index (-0.004), protein content in seed (-0.013), plant height (-0.017), pod length (-0.139) and straw yield per plant (-0.175).

4. Chlorophyll content in leaves: chlorophyll content in leaves (0.173) indicated positive direct effect on seed yield per plant, while it expressed positive indirect effect via biological yield (0.954), dry matter content (0.041), no. of pod per plant (0.016), dry weight at flower initiation (0.008), 1000 seed weight (0.006), no. of branch per plant (0.000). While, negative indirect correlation via pod length (-0.007), Days to 50% flowering (-0.009), protein content in seed (-0.010), plant height (-0.024), no. of seeds per pod (-0.025), harvest index (-0.146), and straw yield per plant (-0.574).

5. No. of pods per plant: No. of pods per plant (0.043) indicated positive direct effect on seed yield per plant, while it expressed indirect positive effect via biological yield (1.566), dry matter content (0.106), chlorophyll content in leaves (0.066), no. of seeds per pod (0.039), dry weight at flower initiation (0.027), days to 50% flowering (0.014) and 1000 seed weight (0.004), no. of branch per plant (0.000). However, the negative indirect effects of this trait were high via plant height (-0.017), protein content in seed (-0.017), pod length (-0.039), harvest index (-0.213) and straw yield per plant (-0.900).

6. No. of seeds per pod: No. of seeds per pod (0.171) expressed high positive direct correlation on seed yield per plant, while it expressed positive indirect correlation via biological yield (0.395), harvest index (0.112), dry matter content (0.079), dry weight at flower initiation (0.054), no. of pods per plant (0.010), Days to 50% flowering (0.007) and 1000 seed weight (0.004), no. of branch per plant (0.000). However, negative indirect correlation via plant height (-0.011), chlorophyll content in leaves (-0.025), protein content in seed (-0.031), straw yield per plant (-0.096) and pod length (-0.185).

7. Pod length: Pod length (-0.239) expressed negative direct effect on seed yield per plant, while it expressed indirect negative effect via protein content in seed (-0.024), plant height (-0.036), straw yield per plant (-0.061). However, the positive indirect effects of this trait were high via biological yield (0.456), harvest index (0.177), dry matter content (0.133), no. of pods per plant (0.007j), dry weight at flower initiation (0.065), days to 50% flowering (0.025), no. of pods per plant (0.007), chlorophyll content in leaves (0.005) and 1000 seed weight (0.005), no. of branch per plant (0.000).

8. Biological yield per plant: Biological yield (1.841) indicated high positive direct effect on seed yield per plant, while it expressed positive indirect correlation via no. of pods per plant (0.337), dry matter content (0.148), chlorophyll content in leaves (0.090), no. of seeds per pod (0.037), dry weight at flower initiation (0.022), Days to 50% flowering (0.014) and 1000 seed weight (0.007), no. of branch per plant (0.000). While the expressed high negative indirect correlation via protein content in seed (-0.012), plant height (-0.025), pod length (-0.059), harvest index (-0.302) and straw yield per plant (-1.055).

9. Straw yield per plant: Straw yield (-1.089) indicated negative direct effect on seed yield per plant, while it expressed negative indirect correlation via protein content in seed (-0.005), pod length (-0.013), plant height (-0.020) and harvest index (-0.376), While the expressed high positive indirect correlation via Biological yield (1.785), dry matter content (0.125), chlorophyll content in leaves (0.091), no. of pods per plant (0.036), dry weight at flower initiation (0.018), no. of seeds per pod (0.0015), 1000 seed weight (0.006) and Days to 50% flowering (0.003), no. of branch per plant (0.000).

10. Protein content in seed: protein content in seed (-0.055) indicated negative direct effect on seed yield per plant, while it expressed negative indirect correlation via plant height (-0.006), straw yield per plant (-0.104), pod length (-0.106). While the expressed high positive indirect correlation via Biological yield (0.392), harvest index (0.164), no. of seeds per pod (0.097), dry matter content (0.088), chlorophyll content in leaves (0.031), dry weight at flower initiation (0.027), no. of pods per plant (0.014), Days to 50% flowering (0.006) and 1000 seed weight (0.003), no. of branch per plant (0.000).

11. Days to 50 % flowering: Days to 50% flowering (-0.084) indicated negative direct effect on seed yield per plant, while it expressed negative indirect effect via 1000 seed weight (-0.005), no. of pods per plant (-0.007), no. of seeds per pod (-0.015), chlorophyll content in leaves (-0.018), dry matter content (-0.062), harvest index (-0.205) and Biological yield (-0.308).While positive indirect correlation via pod length (0.072), straw yield per plant (0.044), plant height (0.009), protein content in seed (0.004) and dry weight at flower initiation (0.002), no. of branch per plant (0.000).

12. 1000 seed weight: 1000 seed weight (0.011) expressed positive direct correlation on seed yield per plant, while it indicated positive indirect correlation via biological yield (1.121), dry matter content (0.103), chlorophyll content in leaves (0.101), no. of seeds per pod (0.066), Days to 50% flowering (0.036), dry weight at flower initiation (0.034) and no. of pods per plant (0.016), no. of branch per plant (0.000). While it expressed negative indirect correlation via protein content in seed (-0.015), plant height (-0.040), harvest index (-0.052), pod length (-0.111), and straw yield per plant (-0.579).

13. Dry matter content: Dry matter content (0.197) indicated high positive direct effect on seed yield per plant, while it expressed indirect positive effect via Biological yield (1.379), no. of seeds per pod (0.068), chlorophyll content in leaves (0.036), dry weight at flower initiation (0.028), no. of pods per plant (0.026), Days to 50% flowering (0.026) and 1000 seed weight (0.006). However, negative indirect correlation via protein content in seed (-0.024), plant height (-0.034), harvest index (-0.096), pod length (-0.161) and straw yield per plant (-0.688).

14. Harvest index: Harvest index (0.498) expressed high positive direct correlation on seed yield per plant, while it indicated positive indirect correlation via straw yield per plant (0.882), no. of seeds per pod (0.039), Days to 50% flowering (0.034) and plant height (0.010).While it expressed negative indirect correlation via 1000 seed weight (-0.001), dry weight at flower initiation (-0.001), protein content in seed (-0.018), no. of pods per plant (-0.018), dry matter content (-0.038), chlorophyll content in leaves (-0.051), pod length (-0.085) and Biological yield (-1.117).

Phenotypic path coefficient

Direct and Indirect effects: The results are presented in Table 4.6.

1. Plant height: Plant height (-0.079) indicated negative direct effect on seed yield per plant, while it expressed indirect negative effect via protein content in seed (-0.001), no. of pods per plant (-0.004), dry matter content (-0.004), harvest index (-0.067) and straw yield per plant (-0.189). However the positive indirect effect of this trait were high via biological yield (0.583) but it was negligible via 1000 seed weight (0.018), chlorophyll content in leaves (0.017), dry weight at flower initiation (0.014), pod length (0.004), Days to 50% flowering (0.003), no. of seeds per pod (0.000) and No. of branches per plant (0.000).

2. Number of branches per plant: No. of branches per plant (0.046) showed positive direct effect on seed yield per plant, while it expressed indirect positive effect via biological yield (0.511), harvest index (0.020), chlorophyll content in leaves (0.013), 1000 seed weight (0.009), Days to 50% flowering (0.001) and no. of seeds per pod (0.000). However, negative indirect correlation via plant height (-0.001), pod length (-0.001), dry matter content (-0.002), protein content in seed (-0.003), dry weight at flower initiation (-0.005), no. of pods per plant (-0.006) and straw yield per plant (-0.181).

3. Dry weight of plant at flower initiation: dry weight at flower initiation (0.064) showed positive direct effect on seed yield per plant, while it expressed indirect positive effect via biological yield (0.290), harvest index (0.019), 1000 seed weight (0.008), pod length (0.005), chlorophyll content in leaves (0.003) and no. of seeds per pod (0.001). However, the negative indirect effect of this trait was high via Days to 50% flowering (-0.001), dry matter content (-0.002), protein content in seed (-0.002), no. of pods per plant (-0.004), no. of branch per plant (-0.004), plant height (-0.017), and straw yield per plant (-0.103).

4. Chlorophyll content in leaves: chlorophyll content in leaves (0.049) indicated positive direct effect on seed yield per plant, while it expressed positive indirect effect via biological yield (0.749), 1000 seed weight (0.017), no. of branch per plant (0.012), dry weight at flower initiation (0.004), Days to 50% flowering (0.002) and no. of seeds per pod (0.000). While, negative indirect correlation via pod length (-0.001), protein content in seed (-0.001), dry matter content (-0.002), No. of pods per plant (-0.006), plant height (-0.027), harvest index (-0.148), and straw yield per plant (-0.359).

5. No. of pods per plant: No. of pods per plant (-0.017) indicated negative direct effect on seed yield per plant, while it expressed indirect negative effect via protein content in seed (-0.002), dry matter content (-0.004), plant height (-0.019), harvest index (-0.220) and straw yield per plant (-0.623). However, the positive indirect effects of this trait were high via biological yield (1.379), chlorophyll content in leaves (0.017), no. of branch per plant (0.016), dry weight at flower initiation (0.014), 1000 seed weight (0.012), Days to 50% flowering (0.005), pod length (0.001) and no. of seeds per pod (0.000).

6. No. of seeds per pod: No. of seeds per pod (0.002) expressed positive direct correlation on seed yield per plant, while it expressed positive indirect correlation via biological yield (0.230), harvest index (0.121), dry weight at flower initiation (0.026), 1000 seed weight (0.007), Days to 50% flowering (0.006), pod length (0.006) and no. of branch per plant (0.001). However, negative indirect correlation via dry matter content (-0.002), No. of pods per plant (-0.003), protein content in seed (-0.003), chlorophyll content in leaves (-0.005), straw yield per plant (-0.005) and plant height (-0.010).

Table 4.6: Phenotypic path coefficient of yield and its component characters of fenugreek

Characters	Plant height (cm)	No. of branches/ plant	Dry wt. at flower initiation (g)	Chlorophyll (SPAD Unit)	No. of pods/ plant	No. of seeds/ Pod	Pod length (cm)	Biological yield/plant(g)	Straw yield per plant (gm)	Protein content in seed (%)	Days to 50% flowering	1000 seed wt (g)	Dry matter content (g)	Harvest index
Plant height (cm)	**-0.079**	0.000	0.014	0.017	-0.004	0.000	0.004	0.583**	-0.189	-0.001	0.003	0.018	-0.004	-0.067
No. of branches/ plant	-0.001	**0.046**	-0.005	0.013	-0.006	0.000	-0.001	0.511**	-0.181	-0.003	0.001	0.009	-0.002	0.020
Dry wt. flower initiation (g)	-0.017	-0.004	**0.064**	0.003	-0.004	0.001	0.005	0.290	-0.103	-0.002	-0.001	0.008	-0.002	0.019
Chlorophyll (SPAD Unit)	-0.027	0.012	0.004	**0.049**	-0.006	0.000	-0.001	0.749**	-0359*	-0.001	0.002	0.017	-0.002	-0.148
No. of pods/plant	-0.019	0.016	0.014	0.017	**-0.017**	0.000	0.001	1.379*	-0.623**	-0.002	0.005	0.012	-0.004	-0.220
No. of seeds/pod	-0.010	0.001	0.026	-0.005	-0.003	**0.002**	0.006	0.230	-0.005	-0.003	0.006	0.007	-0.002	0.121
Pod length (cm)	-0.021	-0.002	0.020	-0.002	-0.001	0.001	**0.017**	0.113	0.031	-0.002	0.006	0.006	-0.002	0.143
Biological yield/plant(g)	-0.026	0.013	0.010	0.021	-0.013	0.000	0.001	**1.790****	-0.832**	-0.001	0.004	0.016	-0.006	-0.353
Straw yield per plant (gm)	-0.017	0.009	0.008	0.020	-0.012	0.000	-0.001	1.705**	**-0.874****	-0.001	0.001	0.013	-0.004	-0.463
Protein content in seed (%)	-0.008	0.017	0.014	0.028	-0.005	0.001	0.004	0.338*	-0.075	**-0.007**	0.002	0.008	-0.004	0.143
Days to 50% flowering	0.007	-0.001	0.020	-0.020	0.003	0.000	-0.003	-0.190	0.109	0.000	**-0.035**	-0.012	0.002	-0.164
1000 seed wt (g)	-0.044	0.012	0.016	0.025	-0.006	0.001	0.003	0.858**	-0.348*	-0.002	0.013	**0.033**	-0.004	-0.059
Dry matter content (g)	-0.039	0.008	0.013	0.029	-0.008	0.001	0.005	1.136**	-0.432**	-0.003	0.008	0.014	**-0.009**	-0.064
Harvest index	0.009	0.001	0.020	-0.012	0.006	0.000	0.004	-1.025**	0.655**	-0.002	0.009	-0.003	0.001	**0.617****

** 1% level of significance
* 5% level of significance

7. Pod length: Pod length (0.017) expressed positive direct effect on seed yield per plant, while it expressed indirect positive effect via harvest index (0.143), biological yield (0.113), straw yield per plant (0.031) dry weight at flower initiation (0.020), 1000 seed weight (0.006), Days to 50% flowering (0.006) and no. of seeds per pod (0.001). However, the negative indirect effects of this trait were high via No. of pods per plant (-0.001), dry matter content (-0.002), chlorophyll content in leaves (-0.002), protein content in seed (-0.002), no. of branch per plant (-0.002) and plant height (-0.021).

8. Biological yield per plant: Biological yield (1.790) indicated high positive direct effect on seed yield per plant, while it expressed positive indirect correlation via chlorophyll content in leaves (0.021), 1000 seed weight (0.016), no. of branch per plant (0.013), dry weight at flower initiation (0.010), Days to 50% flowering (0.004), pod length (0.001) and no. of seeds per pod (0.000). While the expressed high negative indirect correlation via protein content in seed (-0.001), dry matter content (-0.006), No. of pods per plant (-0.013), plant height (-0.026), harvest index (-0.353) and straw yield per plant (-0.832).

9. Straw yield per plant: Straw yield (-0.874) indicated negative direct effect on seed yield per plant, while it expressed negative indirect correlation via protein content in seed (-0.001), pod length (-0.001), dry matter content (-0.004), No. of pods per plant (-0.012), plant height (-0.017) and harvest index (-0.463). While the expressed high positive indirect correlation via Biological yield (1.705), chlorophyll content in leaves (0.020), 1000 seed weight (0.013), no. of branch per plant (0.009), dry weight at flower initiation (0.008), Days to 50% flowering (0.001) and no. of seeds per pod (0.000).

10. Protein content in seed: protein content in seed (-0.007) indicated negative direct effect on seed yield per plant, while it expressed negative indirect effect via dry matter content (-0.004), no. of pods per plant (-0.005), plant height (-0.008) and straw yield per plant (-0.075). While positive indirect correlation via biological yield (0.338), harvest index (0.143), chlorophyll content in leaves (0.028), no. of branch per plant (0.017), dry weight at flower initiation (0.014), 1000 seed weight (0.008), pod length (0.004), Days to 50% flowering (0.002) and no. of seeds per pod (0.001).

11. Days to 50 % flowering: Days to 50% flowering (-0.035) indicated negative direct effect on seed yield per plant, while it expressed negative indirect correlation via no. of branch per plant (-0.001), pod length (-0.003), 1000 seed weight (-0.012), chlorophyll content in leaves (-0.020), harvest index (-0.164) and biological yield (-0.190). While the expressed high positive indirect correlation via straw yield per plant (0.109), dry weight at flower initiation (0.020), plant height (0.007), No. of pods per plant (0.003), dry matter content (0.002), no. of seeds per pod (0.000) and protein content in seed (0.000).

12. 1000 seed weight: 1000 seed weight (0.033) indicated high positive direct effect on seed yield per plant, while it expressed indirect positive effect via Biological yield (0.858), chlorophyll content in leaves (0.025), dry weight at flower initiation (0.016), Days to 50% flowering (0.013), no. of branch per plant (0.012), pod length (0.003) and no. of seeds per pod (0.001). However, negative indirect correlation via protein content in seed (-0.002), dry matter content (-0.004), No. of pods per plant (-0.006), plant height (-0.044), harvest index (-0.059) and straw yield per plant (-0.348).

13. Dry matter content: Dry matter content (-0.009) expressed negative direct correlation on seed yield per plant, while it indicated negative indirect correlation via protein content in seed (-0.003), No. of pods per plant (-0.008), plant height (-0.039), harvest index (-0.064) and straw yield per plant (-0.432). While it expressed positive indirect correlation via biological yield (1.136), chlorophyll content in leaves (0.029), 1000 seed weight (0.014), dry weight at flower initiation (0.013), no. of branch per plant (0.008), Days to 50% flowering (0.008), pod length (0.005) and no. of seeds per pod (0.001).

14. Harvest index: Harvest index (0.617) expressed high positive direct correlation on seed yield per plant, while it indicated positive indirect correlation via straw yield per plant (0.665), dry weight at flower initiation (0.020), Days to 50% flowering (0.009), plant height (0.009), No. of pods per plant (0.006), pod length (0.004), no. of branch per plant (0.001), dry matter content (0.001) and no. of seeds per pod (0.000).While it expressed negative indirect correlation via protein content in seed (-0.002), 1000 seed weight (-0.003), chlorophyll content in leaves (-0.012) and biological yield (-1.025).

5. DISCUSSION

The experimental finding of the present investigation "Variability and Correlation Analysis in Fenugreek (*Trigonella foenum-graecum* L.)" has been discussed in light of the available literature in order to justify the results obtained in previous chapter.

The study emphasized growth and yield parameters for illustrating the performance of different genotypes of fenugreek with respect to various productivity parameters.

The discussion has been classified under the following heads:

A. Growth parameters

B. Yield parameters

C. Quality parameters

D. Study of genetic parameters

1) Genetic variability

2) Heritability

3) Genetic advance as percentage of mean

E. Correlation coefficient studies

F. Path coefficient analysis

A. GROWTH PARAMETERS

Growth parameters *viz*. plant height, number of branches per plant, dry weight at flower initiation, days to 50% flowering. These are the canopy parameters, which were influenced by the community architecture. The canopy components varied from genotype to genotype affect the yield and genotypes.

The genotype RMT-143 recorded maximum plant height followed by UM-36 and UM-30 while the lowest was observed in RMT-305 had shown the lowest plant height. These findings are in accordance with the findings of Kohli *et al.* (1988), Sarada *et al.* (2008) and Gangopadhyay *et al*. (2009). The genotype RMT-305 recorded maximum number of branches per plant followed by NRCSS-AM-2 and RMT-143, while, UM-27 had shown the lowest number of branches. Similar finding were reported by Singh and Raghuwanshi (1984), Verma and Korla (2003), Banerjee and Kole (2004).The variation in number of branches per plant may be due to inherent character of individual variety and should be considered while planning for canopy of plants. AFg-2 recorded maximum dry weight at flower initiation followed by UM-36 and RMT-143, while, Local-1 had shown the lowest dry weight of plant. Days taken to 50% flowering was recorded differ from genotype to genotype. Number of days taken from the date of sowing to when 50% of the plants bear flowers, The flowering ranged from (48.41) days UM-7 to (53.33) days UM-34. Similar finding was reported by Prajapati *et al.* (2010), Dashora *et al.* (2011), Naik *et al.* (2011).

B. YIELD PERAMETERS

The yield of any crop depends on many characters *viz*. number of pods per plant, number of seeds per pod, pod length, seed yield per plant, 1000 seed weight, biological yield straw yield per plant, dry matter content and harvest index. These all characters are control by number of genes and influenced by environmental conditions.

Genotype RMT-143 recorded higher number of pods per plant followed by UM-36 and UM-29.The minimum number of pods per plant was recorded in genotype RMT-303.Hence in the case even after the maximum number of pods per plant. Genotype RMT-303 did not recorded the maximum yield due to poor pod filling caused by climatic requirement. Similar findings are reported by Kohli *et al*. (1988), Sarada *et al.* (2008), Prajapati *et al*. (2010). In case of no. of seeds per pod the maximum number of pod was found in genotype RMT-143 has recorded higher number of seed per pod followed by UM-36, UM-7 and lowest number of seed per pod observed in genotype UM-35. Similar finding was reported by Dash and Kole (2001), Kumar and Choudhary (2003), Gangopadhyay *et al.* (2009). Genotype UM-7 recorded for highest pod length followed by genotype UM-36, RMT-143, while minimum pod length was recorded in genotype UM-352. Similar finding was reported by Dash and Kole (2001), Sarada *et al.* (2008), Singh and Pramila (2009). Genotype UM-36 has recorded for maximum 1000 seed weight followed by RMT-143 and UM-351 while minimum test weight was found in genotype UM-35.This is accordance with finding of Kohli *et al*. (1988), Dash and Kole (2001), Kumar and Choudhary (2003).

Genotype UM-36 has recorded for maximum biological yield followed by UM-32 and RMT-143. The minimum biological yield per plant was recorded in genotype UM-2. Similar finding was reported by Sharma and Sastry (2008).Genotype UM-32 has recorded for maximum straw yield followed by UM-29 and UM-36. The minimum straw yield per plant was recorded in genotype UM-18. Similar finding was reported by Sharma and Sastry (2008).Genotype RMT-143 has recorded for maximum dry matter content followed by UM-36 and UM-29.The minimum dry matter content of per plant was recorded in genotype UM-2. Similar finding was reported by Kohli *et al.* (1988). Genotype UM-18 has recorded for maximum harvest index followed by RMT-305 and UM-2.The minimum harvest index of per plant was recorded in genotype UM-32. Similar finding was reported by Dashora *et al.* (2011).

The highest yield was recorded in RMT-143 (17.03g) per plant which was also high no. of seeds per pod (17.47), pods per plant (81.14),1000 seed weight (17.93g) and plant height (74.83cm), biological yield (46.37g) and dry matter content (75.23g) was followed by UM-36 which seed yield per plant (16.22g) in which the pods per plant (79.13), seeds per pod (17.10),1000 seed weight (19.10g) and biological yield (46.83g).

Lowest seed yield was recorded UM-116 (9.77g), the plant height (63.93), no. of branch per plant (14.87), 1000 seed weight (12.57g), dry matter content (42.85g), straw yield per plant (18.62g) and biological yield per plant (26.63). Similar finding was reported by Sarada *et al.* (2008), Prajapati *et al*. (2010) and Gangopadhyay *et al.* (2009).

C. QUALITY PARAMETERS

The quality of any crop depends on many characters viz. chlorophyll content in leaves (spad unit) and protein content in seed (%). These both characters are control by number of genes and influenced by environmental conditions.

Genotype AFg-2 recorded maximum chlorophyll content in leaves followed by UM-351 and RMT-143.The minimum chlorophyll content in leaves was recorded in genotype RMT-303. Genotype RMT-143 recorded maximum protein content in seed followed by UM-36 and AFg-2.The minimum protein content in seed was recorded in genotype Local-1. Similar finding may reported by Chandra *et al*. (2000) and Balai *et al.* (2006).

D. Study of genetic parameters

Nature and extent of variability is very important from the selection point of view for many crop improvement programmes. It is a tool of plant breeder for selection of desirable traits in crop plants, greater the genetic variability, effective will be the selection in crop breeding programme. Hence, the attempt has been made to ascertain the variability presenting different genotypes of fenugreek.

Variability

The analysis of variance revealed that estimated of mean sum of squares for all the characters were significant at 5% level of probability, indicating the large variation amongst the genotypes. Range for almost all characters was also wide indicating large variability among the genotypes.

Estimates of phenotypic coefficients of variation were higher in magnitude than their corresponding genotypic coefficients of variation for all the characters, indicating the masking influence of environmental factors in expression of these traits. Plant height, number of branches per plant, dry weight at flower initiation, days to 50% flowering, number of pods per plant, no. of seeds per pod, pod length, 1000 seed weight, seed yield per plant, biological yield, straw yield, dry matter content, harvest index, chlorophyll content and protein content had among the above character wide variability were occurred in dry matter content per plant followed by no. of pods per plant, plant height, harvest index, biological yield per plant and straw yield per plant. This indicted the presence of sufficient amount of genetic variability for these traits and can be exploited by breeding procedure for the improvement of these characters. This is accordance with finding of Hariharan and Vijaya Kumar (1997) and Sharma *et al.* (2009).

The difference between the value of PCV and GCV was narrow for dry matter content, no. of seed per pod, 1000 seed weight and plant height, which indicated that phenotype, was truly corresponding by their genotype for these characters.

Characters like no. of pod per plant, protein content in seed, days to 50% flowering and dry weight at flower inition were found to be consistent in its behavior, both at phenotypic and genotypic level having lowest coefficient of variation. It suggested that these traits were least influenced by the non genetic factors and were hence quite stable. This is accordance with finding of Chandra *et al.* (2000), Dash and Kole (2001), Banerjee and Kole (2004) and Naik (2012).

Heritability

Heritability provided of genetic variation i.e. the variation upon which all the possibilities of changing the genetic composition of the population through selection is dependent. The heritability estimates in broad sense were classified into three groups. High more than 70 medium 50 to 70 and low less than 50.

In present investigation broad sense heritability estimates were high for, protein content in seed(96.9), followed by no. of pods per plant (96.7), dry weight at flower initiation (89.7), chlorophyll content in leaves(87.10), 1000 seed weight (84.8), dry matter content (80.4), biological yield per plant (78.2), plant height (78.2),straw yield per plant(71.0), days to 50% flowering (69.4), seed yield per plant (68.9), no. of seeds per pod (65.4), harvest index (58.1), no. of branches (34.2), pod length (24.4).Similar findings were reported by Chandra *et al.* (2000), Verma and Korla (2003), Dashora *et al.* (2011), Meena *et al.* (2011) and Naik (2012).

Genetic advance

The genetic advance is more useful than heritability alone in predicting the resultant effect on selecting best individuals. In the present investigation, expected genetic advance was recorded high with dry matter content (17.83), followed by no. of pods per plant (17.39), biological yield (10.75), plant height (10.50), straw yield per plant (7.89), chlorophyll content in leaves(6.98), harvest index(6.62), protein content in seed(5.84), days to 50% flowering (3.56), 1000 seed weight (3.55), seed yield per plant (2.84), dry weight at flower initiation (1.61), no. of seeds per pod (1.53), no. of branches per plant (1.13) and pod length (0.40).This is accordance with finding of Prajapati *et al*. (2010) and Naik (2012).

Genetic advance percentage of mean

Heritability estimates along with the genetic advance are more useful than heritability alone in predicting the resultant effect on selecting best individuals. In the present investigation, expected genetic advance expressed as percentage of mean was high for straw yield per plant(31.66%), followed by dry matter content (31.56%), protein content in seed(30.88%), biological yield (28.95%), no. of pods per plant (26.05%), 1000 seed weight (24.63%), seed yield per plant (22.73%), harvest index (19.36%), plant height (15.93%), dry weight at flower initiation (14.70%), chlorophyll content in leaves(12.89%), no. of seeds per pod (9.87%), no. of branches per plant (7.73%), days to 50% flowering (7.35%) and pod length (3.59%).High heritability and high genetic advance was observed for the above characters indicated that these characters are governed by additive gene action. Hence, these are good chances of improvement of these traits through direct selection in the present material. Johnson *et al*. (1955) also pointed out that heritability values along with genetic advance were more useful than heritability alone for selecting the best individuals. The several studies have also shown importance by various scientists reported by Verma and Korla (2003), Datta and Chatterjee (2004) and Naik (2012).

E. Correlation studies

Correlation coefficient measures the relationship between two or more variables. It helps in determining component characters for a complex character *viz*., seed yield per plant. Yield is a manifestation of interaction of number of factors. Direct selection for yield may not be very effective. However indirect selection through component traits may give desired results.

The degrees of interrelationship among the characters vary from trait to trait. In general, the estimates of genotypic correlation coefficient were higher than their corresponding phenotypic correlation coefficient values for most of the characters under study.

The correlation coefficients were interpreted on the basis of the following inferences. If the value of correlation coefficient is negative in sign, it means that increase in one parameter will lead to decrease in second parameters and the vice versa. The results are presented in table (4.3).

Genotypic correlation coefficient

Plant height had highly significant positive correlation with 1000 seed weight, pod length, dry matter content, biological yield, seed yield per plant, chlorophyll content in leaves, straw yield per plant, but positive correlation with no. of pods per plant, dry weight at flower initiation, no. of seeds per pod, protein content in seed while it was negative with No. of branches, days to 50% flowering and harvest index. Similar findings have been reported by Singh and Raghuwanshi (1989), Chandra *et al.* (2000) and Kole *et al.* (2013). No. of branches per plant had significant positive correlation with protein content in seed, chlorophyll content in leaves, no. of pods per plant, seed yield per plant, 1000 seed weight, biological yield per plant, straw yield per plant, but positive correlation with no. of seeds per pod, dry matter content, while it was negative with pod length, harvest index, dry weight at flower initiation and days to 50% flowering. Similar findings have been reported by Pant *et al*. (1984) and Singh and Raghuwanshi (1989).

The dry weight at flower initiation had highly significant positive correlation with pod length, no. of seeds per pod, but positive correlation with 1000 seed weight, seed yield per plant, dry matter content, protein content in seed, no. of pods per plant, biological yield, straw yield per plant, chlorophyll content in leaves, days to 50% flowering, While, it was negative with harvest index. Similar findings have been reported by Kohli *et al*. (1988), Singh and Raghuwanshi (1989) and Banerjee and Kole (2004). The chlorophyll content in leaves had highly significant positive correlation with 1000 seed weight, straw yield per plant, biological yield, seed yield per plant, no. of pods per plant but positive correlation with dry matter content, protein content in seed, pod length, while it was negative with days to 50% flowering, no. of seeds per pod and harvest index.

No. of pods per plant had highly significant positive correlation with biological yield, straw yield per plant, seed yield per plant, dry matter content, 1000 seed weight but positive correlation with no. of pods per plant, protein content in seed, pod length. While, negative correlation with days to 50% flowering, and harvest index. Similar findings have been reported by Chandra *et al.* (2000) and Dash and Kole (2000), Datta *et al.* (2005) and Kole *et al.* (2013). The no. of seeds per pod had highly significant positive correlation with pod length, protein content in seed, seed yield per plant, dry matter content, 1000 seed weight but positive correlation with harvest index, biological yield and straw yield per plant while negative correlation with days to 50% flowering. Similar findings have been reported by Datta *et al.* (2005), Dash and Kole (2000).

The pod length had positive correlation with dry matter content, seed yield per plant, 1000 seed weight, protein content in seed, harvest index but positive correlation with biological yield, straw yield per plant while negative correlation with days to 50% flowering. The biological yield had highly significant positive correlation with straw yield per plant, dry matter content, seed yield per plant, 1000 seed weight but positive correlation with protein content in seed while negative correlation with days to 50% flowering and harvest index. Similar findings have been reported by Kumar and Choudhary (2002) and Sharma and Sastry (2008). The straw yield per plant had highly significant positive correlation with dry matter content, seed yield per plant, 1000 seed weight but positive correlation with protein content in seed while negative correlation with days to 50% flowering and harvest index. Similar findings have been reported by Dash and Kole (2000), Saha and Kole (2001) and Kole *et al.* (2013). The protein content had highly significant positive correlation with seed yield per plant, dry matter content but positive correlation with harvest index, 1000 seed weight while negative correlation with days to 50% flowering. Similar findings have been reported by Chandra *et al*. (2000), Balai *et al.* (2006), Dashora *et al.* (2011) and Fikreselassie *et al.* (2012)

The Days to 50% flowering negative correlation with dry matter content, harvest index, 1000 seed weight and seed yield per plant. Similar findings have been reported by Kohli *et al*. (1988), Singh and Raghuwanshi (1989) and Banerjee and Kole (2004). The 1000 seed weight had highly significant positive correlation with seed yield per plant and dry matter content while negative correlation with harvest index. Similar findings have been reported by Sharma and Sastry (2008).

The dry matter content had highly significant positive correlation with seed yield per plant while negative correlation with harvest index. This is accordance with finding of Kohli *et al*. (1988), Hariharan and Vijaya Kumar (1997).The harvest index significant positive correlation with seed yield per plant. Similar findings have been reported by Dash and Kole (2000), Saha and Kole (2001) and Kole *et al.* (2013).

The seed yield per plant had highly significant positive correlation with dry matter content, biological yield, 1000 seed weight, no. of pods per plant, pod length, straw yield per plant, protein content in seed, no. of branches, no. of seeds per pod, chlorophyll content in leaves, plant height, dry weight at flower initiation, but it was positively non significantly correlated with harvest index while negative correlation with while negative correlation with days to 50% flowering. Similar findings have been reported by Kumar and Choudhary (2002), Singh *et al.* (2006) and Sarada *et al*. (2008).

Phenotypic correlation coefficient

The plant height had highly significant positive correlation with 1000 seed weight, dry matter content, chlorophyll content in leaves but positive correlation with biological yield, seed yield per plant, pod length, no. of pods per plant, dry weight at flower initiation, straw yield per plant, no. of seeds per pod, protein content in seed, No. of branches, while it was negative with days to 50% flowering and harvest index. No. of branches had significant positive correlation with seed yield per plant, protein content in seed, no. of pods per plant but positive correlation with biological yield per plant, 1000 seed weight, chlorophyll content in leaves, straw yield per plant, dry matter content, harvest index, no. of seeds per pod while it was negative with days to 50% flowering pod length and dry weight at flower initiation. The dry weight at flower initiation had highly significant positive correlation with no. of seeds per pod but positive correlation with pod length, seed yield per plant, 1000 seed weight, protein content in seed, no. of pods per plant, dry matter content, biological yield, straw yield per plant, chlorophyll content in leaves, harvest index and days to 50% flowering.

The chlorophyll content in leaves had highly significant positive correlation with 1000 seed weight, biological yield, straw yield per plant, no. of pods per plant but positive correlation with seed yield per plant, dry matter content, protein content in seed while it was negative with harvest index, days to 50% flowering, pod length and no. of seeds per pod. The no. of pods per plant had highly significant positive correlation with biological yield, straw yield per plant, seed yield per plant, dry matter content, 1000 seed weight but positive correlation with protein content in seed, no. of pods per plant , pod length while negative correlation with days to 50% flowering, and harvest index. The no. of seeds per pod had highly significant positive correlation with protein content in seed, pod length, seed yield per plant but positive correlation with dry matter content, 1000 seed weight, harvest index, biological yield and straw yield per plant while negative correlation with days to 50% flowering.

The pod length had positive correlation with seed yield per plant but positive correlation with dry matter content, harvest index, protein content in seed, 1000 seed weight, biological yield while negative correlation with straw yield per plant and days to 50% flowering. The biological yield had highly significant positive correlation with straw yield per plant, dry matter content, seed yield per plant, 1000 seed weight but positive correlation with protein content in seed while negative correlation with days to 50% flowering and harvest index. The straw yield per plant had highly significant positive correlation with dry matter content, 1000 seed weight, seed yield per plant but positive correlation with protein content in seed while negative correlation with days to 50% flowering and harvest index. The protein content had highly significant positive correlation with seed yield per plant, dry matter content but positive correlation with 1000 seed weight, harvest index, while negative correlation with days to 50% flowering.

The Days to 50% flowering negative correlation with dry matter content, harvest index, 1000 seed weight and seed yield per plant. The 1000 seed weight had highly significant positive correlation with seed yield per plant and dry matter content while negative correlation with harvest index. The dry matter content had highly significant positive correlation with seed yield per plant while negative correlation with harvest index, The harvest index significant positive correlation with seed yield per plant.

The seed yield per plant had highly significant positive correlation with dry matter content, biological yield, no. of pods per plant, 1000 seed weight, protein content in seed, no. of branches, straw yield per plant, no. of seeds per pod, but it was positively non significantly correlated with pod length, plant height, chlorophyll content in leaves, harvest index, dry weight at flower initiation while negative correlation with while negative correlation with days to 50% flowering.

F. Path coefficient analysis

Correlation coefficient simply measures the association between the two characters without providing any information about cause of association. Under such circumstance the association becomes more complex and confusing. The path coefficient analysis helps to avoid complication by measuring the direct and indirect influence of one variable upon the other by partitioning the correlation coefficient into the component of direct and indirect effects, revealing the causes of association between characters. Thus the real contribution of each component to the end product could be assessed, so that judicious selection of traits can be made for effective gain in characters under consideration for improvement.

In the present investigation path coefficient analysis was carried out for characters under study using genotypic and phenotypic correlation coefficient and taking seed yield per plant as dependable variable, in order to see the causal factor and also to identify the components which are responsible for producing seed yield per plant.

Genotypic path analysis of the different characters revealed that biological yield, had highest positive direct effect on seed yield per plant followed by harvest index, dry matter content, chlorophyll content in leaves, no. of seeds per pod, dry weight at flower initiation, no. of pods per plant, 1000 seed weight, no. of branches per plant. The straw yield per plant and pod length had the highest negative direct effect on seed yield followed by days to 50% flowering, plant height and protein content in seed. The positive indirect effect on seed yield via. Harvest index.

Phenotypic path analysis of the different characters revealed that biological yield per plant had highest positive direct effect on seed yield per plant followed by harvest index, dry weight at flower initiation, chlorophyll content in leaves, no. of branches per plant and 1000 seed weight. Straw yield per plant and Plant height had the highest negative direct effect on seed yield. The positive indirect effect on seed yield via. Harvest index. Traits viz. Straw yield per plant and Plant height imparted negative direct effect on seed yield per plant. Thus, increasing seed yield per plant direct selection for these traits should be avoided instead indirect selection should be more appropriate to apply.

Path coefficient analysis revealed that biological yield per plant harvest index, dry weight at flower initiation, chlorophyll content in leaves, no. of branches per plant and 1000 seed weight are the most important characters. (Contributing towards) field and hence purposeful and balanced selection based on these traits would be more rewarding for improvement of fenugreek. The several studies have shown importance by various scientists reported by Pant *et al*. (1984), Kohli *et al.* (1988), Singh and Raghuwanshi (1989), Lowanshi *et al.* (1998) ,Chandra *et al*. (2000), Datta *et al.* (2005), Singh *et al.* (2006), Balai *et al.* (2006), Sharma and Sastry (2008), Dashora *et al.* (2011), Naik *et al.* (2011) and Fikreselassie *et al.* (2012).

6. **SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK**

6.1 Summary

The present investigation entitled "Variability and Correlation Analysis in Fenugreek (*Trigonella foenum-graecum* L.)" was conduct at College of Horticulture Complex, Mandsaur (M.P.) during *Rabi* season 2012–13. This investigation was carried out with 30 varieties including 3 local varieties and 27 commercial varieties in Randomized Block Design (RBD) with three replications.

The result obtain from fifteen characters in present investigation was to measure the genetic variability, heritability and genetic advance as percentage of mean, correlation coefficient and path coefficient analysis amongst different growth, yield and attributing parameters were studied the result obtained from the present investigation are summarized below:

The genotype RMT-143 recorded maximum plant height followed by UM-36 and UM-30 while the lowest was observed in RMT-305 had shown the lowest plant height. The genotype RMT-305 recorded maximum number of branches per plant followed by NRCSS-AM-1 and RMT-143 while, UM-27 had shown the lowest number of branches.

The variation in number of branches per plant may be due to inherent character of individual variety and should be considered while planning for canopy of plants. AFg-2 recorded maximum dry weight at flower initiation followed by UM-36 and RMT-143.While Local-1 had shown the lowest dry weight of plant.

Days taken to 50% flowering was recorded differ from genotype to genotype. Number of days taken from the date of sowing to when 50% of the plants bear flowers. The flowering ranged from (44.41) days UM-7 to (53.33) days UM-34.

Genotype RMT-143 recorded higher number of pods per plant, followed by UM-36 and UM-29.The minimum number of pods per plant was recorded in genotype RMT-303 .Hence in the case even after the maximum number of pods per plant. Genotype RMT-303 did not recorded the maximum yield due to poor pod filling caused by climatic requirement.

In case of no. of seeds per pod the maximum number of pod was found in genotype RMT-143 has recorded higher number of seed per pod followed by UM-36, UM-7 and lowest number of seed per pod observed in genotype UM-35.

Genotype UM-7 recorded for highest pod length followed by genotype UM-36, RMT-143 while minimum pod length was recorded in genotype UM-352. Genotype UM-36 has recorded for maximum 1000 seed weight followed by RMT-143 and UM-351 while minimum test weight was found in genotype UM-35.

Genotype UM-36 has recorded for maximum biological yield followed by UM-32 and RMT-143. The minimum biological yield per plant was recorded in genotype UM-29. Genotype UM-32 has recorded for maximum straw yield followed by UM-29 and um-36. The minimum straw yield per plant was recorded in genotype UM-18.

Genotype RMT-143 has recorded for maximum dry matter content followed by UM-36 and UM-29.The minimum dry matter content of per plant was recorded in genotype UM-2. Genotype UM-18 has recorded for maximum harvest index followed by RMT-305 and UM-2.The minimum harvest index of per plant was recorded in genotype UM-32.

Genotype AFg-2 has recorded for maximum chlorophyll content in leaves followed by UM-351 and RMT-143.The minimum chlorophyll content in leaves was recorded in genotype RMT-303. Genotype RMT-143 has recorded for maximum protein content in seed followed by UM-36 and AFg-2.The minimum protein content in seed of per plant was recorded in genotype Local-1.

The highest yield was recorded in RMT-143 per plant which was also high no. of seeds per pod, pods per plant, plant height and dry matter content was followed by UM-36. Lowest was recorded UM-116 which was also the low straw yield per plant, biological yield per plant and dry matter content.

Estimates of phenotypic coefficients of variation were higher in magnitude than their corresponding genotypic coefficients of variation for all the characters, indicating the masking influence of environmental factors in expression of these traits. Variability were occurred in biological yield per plant, followed by dry matter content per plant, no. of pods per plant, plant height, harvest index, biological yield per plant and straw yield per plant. This indicted the presence of sufficient amount of genetic variability for these traits and can be exploited by breeding procedure for the improvement of these characters. The difference between the value of PCV and GCV was narrow for dry matter content, no. of seed per pod, 1000 seed weight and plant height, which indicated that phenotype, was truly corresponding by their genotype for these characters.

In present investigation broad sense heritability estimates were high for, protein content in seed, followed by no. of pods per plant, dry weight at flower initiation, chlorophyll content in leaves, 1000 seed weight, dry matter content, biological yield per plant, plant height, straw yield per plant, days to 50% flowering, seed yield per plant, no. of seeds per pod, harvest index, no. of branches, pod length.

The genetic advance is more useful than heritability alone in predicting the resultant effect on selecting best individuals. In the present investigation, expected genetic advance was recorded high with dry matter content, followed by no. of pods per plant, biological yield, plant height, straw yield per plant, chlorophyll content in leaves, harvest index, protein content in seed, days to 50% flowering, 1000 seed weight, seed yield per plant, dry weight at flower initiation, no. of seeds per pod, no. of branches per plant and pod length.

Heritability estimates along with the genetic advance are more useful than heritability alone in predicting the resultant effect on selecting best individuals. In the present investigation, expected genetic advance expressed as percentage of mean was high for straw yield per plant, followed by dry matter content, protein content in seed, biological yield, no. of pods per plant, 1000 seed weight, seed yield per plant, harvest index, plant height, dry weight at flower initiation, chlorophyll content in leaves, no. of seeds per pod, no. of branches per plant, days to 50% flowering and pod length.

The correlation studies revealed that in most the cases genotypic correlation coefficients were found to be higher magnitude than the corresponding phenotypic ones. The character like seed yield per plant was found to have positive highly significant association with dry matter content, biological yield, 1000 seed weight, no. of pods per plant, pod length, straw yield per plant, protein content in seed, no. of branches, no. of seeds per pod, chlorophyll content in leaves, plant height, dry weight at flower initiation, but it was positively non significantly correlated with harvest index while negative correlation with while negative correlation with days to 50% flowering.

Path analysis of the different characters revealed that biological yield, had highest positive direct effect on seed yield per plant followed by harvest index, dry matter content, chlorophyll content in leaves, no. of seeds per pod, dry weight at flower initiation, no. of pods per plant, 1000 seed weight, no. of branches per plant. The straw yield per plant and pod length had the highest negative direct effect on seed yield followed by days to 50% flowering, plant height and protein content in seed. The positive indirect effect on seed yield via harvest index.

6.2 Conclusion

Information on genetic variability, heritability, genetic advance as percentage of mean, correlation and path analysis is helpful in selecting high yielding genotypes in fenugreek.

Out of 30 genotypes the highest yield was recorded in RMT-143 followed by UM-36 and the lowest yield was recorded UM-116. Same type of result was also obtained from growth parameter variability characteristics and also in heritability and genetic advance. In conclusion we can say that the genotype RMT-143, UM-36 should be used for further advancement for fenugreek crop.

6.3 Suggestion for further work

- Traits identified for high heritability coupled with high or moderate genetic advance may be considered well in selection for the improvement of fenugreek crop.

- Growth analytical studied on different genotypes of fenugreek may be undertaken for locating the best genotypes in respect of source to sink relationship.
- More number of germplasm of fenugreek may be included for critical evaluation of genotypes.
- The superior and high yielding genotype in RMT-143 and UM-36 suitable in Malwa Region.
- Study on estimation of components of genetic variance may be carried out for improvement of yield through component traits.

7. BIBLIOGRAPHY

Al-Jibouri, H. A., Miller, P.A. and Robinson, H.F., (1958). Genotypic and environmental variances and co-variances in an upland cotton cross of interspecific origin. *Agron. Journal*, **50**: 533-536.

Anonymaous (2012). Indian Horticulture Data base-2013, Ministry of Agriculture, Government of India 85, Institutional Area, Sector– 18, Gurgoan-122015, Pp-202-205.

Balai, O.P., Singh, D. and Jain, U.K. (2006). Genetic variation and character association among yield and yield related traits in fenugreek. *Indian Journal of Agricultural Research,* **40** (2):143-146.

Banerjee, A. and Kole, P.C. (2004). Genetic variability, correlation and path analysis in fenugreek. *Journal of Spices Aromatic Crops*, **13** (1): 44-48.

Burton, G.W. (1952). Quantitative inheritance in grasses. Proc. Sixth Inter. Grassland Cong. **1**: 227-283.

Chandra, K., Sastry, E.V.D. and Singh, D. (2000). Genetic variation and character association of seed yield and its component characters in fenugreek. *Agric. Sci. Digest*, **20** (2): 93-95.

Dash, S.R. and Kole, P.C. (2000). Association analysis of seed yield and its components in fenugreek (*Trigonella foenum-graecum* L.). *Crop Research Hissar*, **20** (3): 449-452.

Dash, S.R. and Kole, P.C. (2001). Studies on variability, heritability and genetic advance in fenugreek. *J., Interacademicia*, **5** (1): 7-10.

Dashora, A., Maloo, S. R. and Dashora, L.K. (2011). Variability, correlation and path coefficient analysis in fenugreek (*Trigonella foenum-graecum* L.) under water limited conditions. *Journal of Spices and Aromatic Crops,* **20** (1): 38-42.

Datta, S. and Chatterjee, R. (2004). Performance of fenugreek genotypes under new alluvial zone of West Bengal. *Journal of Spices and Aromatic Crops,* **13** (2): 132-134.

Datta, S., Chatterjee, R. and Mukherjee, S. (2005). Variability, heritability and path analysis studies in fenugreek. *Indian J. Hort*., **62** (1): 96-98.

Dewey, D.R. and Lu, K.H. (1959). A Correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.,* **51**: 515-518.

Fikreselassie, M., Zeleke, H. and Alemayehu, N. (2012). Correlation and Path Analysis in Ethiopian Fenugreek (*Trigonella foenum-graecum L*.) Landraces. *Crown Research in Education,* **2** (3): 132-142.

Fikreselassie, Million, Zeleke, H. and Alemayehu, Nigussie (2012). Genetic variability of Ethiopian fenugreek (*Trigonella foenum-graecum* L.) landraces. *Journal of Plant Breeding and Crop Science,* **4** (3):39-48.

Fisher, R.A. (1954). Statistical method for research workers, Oliver and Boyd. Edeinburgh, 184-189.

Gangopadhyay, K. K., Yadav, S. K., Kumar, G. , Meena, B. L., Mahajan, R. K., Mishra, S. K. and Sharma, S. K. (2009). Correlation, path-coefficient and genetic diversity pattern in fenugreek. *Indian Journal of Agricultural Science,* **79** (7): 521-526.

Hanson, C.H., Robinson, H.F., and Comstock, R.E. (1956). Biometrical studies of yield in segregating populations of Korean, Lespedize. *Agronomy Journal,* **48**: 268 -272.

Hariharan, K. and VijayaKumar, M. (1997). Studies on the genetic variability in fenugreek (*Trigonella foenum-graecum* L.).*South Indian Hort*., **45** (3&4): 143-147.

Johnson, H. W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybeans. *Agron. J.,* **47**: 314-318.

Kohli, U.K., Sharma, O.P. and Singh, Jeet (1988). Genetic variability, correlation and path analysis in fenugreek (*Trigonella foenum-graecum* L.). *Indian Journal of Hort*., **45**:119-125.

Kole, P.C. and Saha, A. (2013). Correlation co-efficients of component characters with seed yield and their direct effects in path analysis in fenugreek grown under six environments. *Journal of Horticulture and Forestry,* **5**(1):17-20.

Kumar, M. and Choudhary, B. M. (2003). Studies on genetic variability in fenugreek *(Trigonella foenum-graecum* L*.).The Orissa Journal of Horticulture*, **31** (1): 37-39.

Kumar, M. and Choudhary, B. M. (2002). Correlation and heritability studies of different characters in fenugreek *(Trigonella foenum-graecum* L*.). The Orissa Journal of Horticulture,* **30** (2): 57-59.

Lowanshi, R. K., Shukla, R. S. Dubey, R. K. and Choubey, P. C. (1998). Association and path coefficient in fenugreek *(Trigonella foenum-graecum* L*.). Advances in Plant Sciences,* **11** (2): 45-50.

Lush, J.L. (1949). Animal Breeding plans. The callectu press. Amer. Gowa, edn.3.

Mathur, V.L. (1996). Correlations and path coefficient analysis in fenugreek (*Trigonella foenum-graecum* L*.). Madras Agric. J.,* **83** (5): 278-279.

Meena, R.S., Kakani, R.K., Anwer, M.M., Panwar, A., Choudhary, S. and Meena, S.R. (2011). Variability studies in fenugreek (*Trigonella foenum-graecum* L*.) International J. Seed Spices* **1** (1): 44-46.

Metson, A.J. (1956). Methods of chemical analysis for soil survey samples. Bull. No. 2, Deptt. Sci. Md. Res. Soil Bur. 12.

Naik, A. (2012). Characterization fenugreek (*Trigonella foenum-graecum*L.) genotypes through morphological characters. *Intl. J. Agric. Env. Biotech.* **5**(4): 453-457.

Naik, A., Akhtar, S., Bhuniam, P. and Pandey, V.P. (2011). Correlation coefficient and path analysis studies in fenugreek (*Trigonella foenum-graecum* L.). *Environment and Ecology*, **29**: 3B, 1546-1549.

Olsen, S.R., Cole, C.V., Watanable, F.S. and Daen, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate [$Na_2(HCO_3)$] U.S.D.A. Circular no. 939-Washington.

Panes, V.G. and Sukhatme, P.V. (1985). Statistical method for agriculture workers. Indian councial of Agriculture Research, New Delhi, 155.

Pant, K.C., Chandel, K. P.S. and Pant, D.C. (1984). Variability and path coefficient analysis in fenugreek. *Indian J. Agric. Sci*., **54** (8): 655-658.

Piper, C.S. (1950). Soil and plant analysis. Inter Science Publishers Inc. New York, USDA.

Prajapati, D. B., Ravindrababu, Y. and Prajapati, B.H. (2010). Genetic variability and character association in fenugreek *(Trigonella foenum-graecum* L.*)*. *Journal of Spices and Aromatic Crops,* **19** (1&2): 61-64.

Richards, L.A. (1956). Diagnosis and improvement of saline and alkali soils. USDA Hand book No. 60.

Saha, A. and Kole, P.C. (2001).Genetic variability in fenugreek *(Trigonella foenum-graecum* L.) grown in sub–humid lateritic belt of West Bengal. *Madras Agricultural Journal,* **88** (4&6): 348-350.

Sarada, C., Giridhar and Rao, Hariprasada. (2008). Studies on genetic variability, heritability and genetic advance in fenugreek (*Trigonella foenum-graecum* L.). *Journal of Spices and Aromatic Crops,* **17** (2):163-166.

Sarada, C., Giridhar, K. and Rao, H.N. (2008). Studies on character association in fenugreek *(Trigonella foenum-graecum* L.*). Journal of Spices and Aromatic Crops,* **17** (2): 82-84.

Sharma, K.C. and Sastry, E.V.D. (2008). Path analysis for seed yield and its component characters in fenugreek *(Trigonella foenum-graecum* L.*). Journal of Spices and Aromatic Crops,* **17** (2): 69-74.

Sharma,K.C., Sharma, M.M. and Sharma, R.K. (1990).Nature of variability and associations in fenugreek. *Indian J. Genet*., **50** (3):260-262.

Singh, J.V., Lodhi, G.P., Arora, R.N., Jhorar, B.S., Kishor, C. and Thakral, N.K. (1993). Association analysis for some quantitative traits in fenugreek (*Trigonella foenum-graecum* L.) *International J. Trop. Agric*., **9** (3): 182-186.

Singh, R.R. and Raghuvanshi, S.S. (1989). Correlation and path coefficient analysis in fenugreek (*Trigonella foenum-graecum* L.). *Indian Journal of Horticulture,* **43**: 294-298.

Singh, S.P. and Pramila (2009). Genetic variability, heritability and genetic advance for quantitative characters in fenugreek (*Trigonella foenum-graecum* L.). *The asian Journal of horticulture,* **4** (1):167-169.

Singh, S.P. and Pramila (2009).Correlation and path analysis in fenugreek (*Trigonella foenum-graecum* L.). *The Asian Journal of Horticulture,* **4** (1): 105-107.

Singh, Y., Dutt, S., Sharma, S. and Sharma, A. (2006). Association of characters and their direct and indirect contribution for seed yield in fenugreek. *(Trigonella foenum-graecum* L.*). Journal of Research,*Skuast-J*,* **5** (2): 0972-7469.

Subhiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Sci.*, **25** (7): 259-260.

Verma, R. and Korla, B.N. (2003). Genetic variability in fenugreek *(Trigonella foenum-graecum* L.) grown under mid-hills of Himachal Pradesh. *Journal of Spices and Aromatic Crops,* **12** (1): 60-62.

Wright, S. (1921). Correlation and causation *J. Agric. Res*., **20**: 557-587.

VITA

The author of this thesis **Mahendra gurjar** was born on 2nd March 1987 at Dewas District (M.P.). He passed his Secondary Examination in the year 2004 and Senior Secondary Examination in the year 2006 from M.P. Board, Bhopal from Govt. Excellence Higher Secondary School Khategaon, Distt. Dewas (M.P). With 40% and 60.00 % marks respectively.

He joined College of Horticulture, Mandsaur in 2007 and completed B.Sc. (Horticulture) in the year 2011 with 1st division securing an OGPA of 6.61 on 10 point scale.

After graduation, he joined M.Sc. (Horticulture) in College of Horticulture, Mandsaur specialization in Plantation, Spice, Medicinal and Aromatic Crops. He has completed the entire course requirement for the above said Master Degree in the year 2012-13 with an OGPA of 7.25 on a 10 point scale.

He was allotted an interesting research problem entitled **"Variability and correlation analysis in fenugreek (*Trigonella foenum graecum* L.)"** of his choice for thesis work, which has been duly completed by him and presented in the form of this thesis.

(Mahendra gurjar)