GENETIC ANALYSIS IN FODDER RICE BEAN (*Vigna umbellata* (Thunb.) FOR YIELD AND QUALITY

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"GENETIC ANALYSIS IN FODDER RICE BEAN (*Vigna umbellata* (Thunb.) FOR YIELD AND QUALITY"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"GENETIC ANALYSIS IN FODDER RICE BEAN (*Vigna umbellata* (Thunb.) FOR YIELD AND QUALITY"** is a record of research work done independently by Miss Bhoomika B K under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variance
%	Per cent
Cm	Centimeter
RBD	Randomized Block Design
DAS	Days After Sowing
et al.	Co-authors/And others
^{0}C	Degree Celsius
Fig.	Figure
G	Gram
g^{-1}	Per gram
Kg	Kilo gram
ha^{-1}	Per hectare
KAU	Kerala Agricultural University
t ha^{-1}	Tonne per hectare
Kg ha^{-1}	Kilogram per hectare
$Plant^{-1}$	Per plant
Day^{-1}	Per day
Via	Through
No.	Number
Sl.	Serial
sp. or spp.	Species (Singular or Plural)
Cv	Cultivar
viz.	Namely
i.e	that is
d.f	Degrees of freedom
S.E	Standard Error
C.D	Critical difference
kg $ha^{-1}day^{-1}$	Kilogram per hectare per day

PCV	Phenotypic Coefficient of Variation
Mt	Metric tones
GCV	Genotypic Coefficient of variation
&	And
GA	Genetic Advance
NBPGR	National Bureau of Plant Genetic Resources
AICRP	All India Coordinated Research Project
AOAC	Association of Official Agricultural Chemist
LAI	Leaf Area Index
GCA	General Combining Ability

INTRODUCTION

1. INTRODUCTION

India is principally an agrarian country with a large livestock population, making animal husbandry an important subsidiary occupation of farmers, especially for small and marginal farmers. Even though India ranks first in milk production, it is not sufficient enough to meet the nutritional requirement of livestock. Proper feeding and management of livestock is very important to obtain good quality milk. This requires a regular supply of green and dry fodder. Fodder crops are the cheapest source of feed for livestock.

Rice bean (*Vigna umbellata* (Thunb) is an underutilized neglected minor legume but nowadays gained importance as a potential nutritious animal fodder and high quality grain legume (Lawn, 1995). It has good forage yield and grain production potential. Being leguminous crop it also increases soil fertility by fixing atmospheric nitrogen. It can also thrive well under adverse climatic conditions, including drought and water logging.

Rice bean is originated in Indo-China, distributed to Thailand and neighboring regions (Tamooka *et al*., 2011), grown naturally in India, China, and Indochinese Pennisula then introduced to Egypt, East Coast Africa and Island of Indian Ocean. In India it is distributed in Western and Eastern Ghats, North East Himalaya, Assam, Mizoram, Meghalaya and Manipur (Jain and Mehra, 1978), it can also be grown in sub temperate Himalayan regions of Uttaranchal and Himachal Pradesh Hills. Centres of diversity are found to be North Eastern regions, Eastern Himalaya, Bengal and Sikkim (Arora, 1988).

Vigna umbellata var. *gracilis* is found to be ancestor of *Vigna umbellata*. It belongs to the family Fabaceae (2n=22). Leaves are trifoliate, leaf lets are broader and hairy, flowers are yellow in colour, borne in clusters. It is a semi erect annual legume; it grows up to three meter height. Some researchers in India have shown that rice bean has highest growth efficiency and lowest respiratory loss and there is evidence of natural outcrossing (Sastrapradja and Sutarno, 1977). Nowadays rice bean is emerging as important leguminous summer fodder crop in India with production potential of 35 tonnes per hectare (Chatterjee and Das, 1989). It can be used as a food fodder and green manure. Rice bean posses wider adaptability from humid sub-tropical to warm and cool temperate regions. Rice bean can be grown under diverse condition with no additional input. It can be grown as an intercrop with maize. It can also be grown as sole crop in the uplands, or on the rice bunds, or in a home garden. It is highly nutritious animal fodder, known to increase the soil fertility, it can also be used as a cover crop to reduce soil erosion. Sown in late May to end of June it can be grown in different types of soil but it does not perform well under shade (Khadka and Acharya, 2009). Being a vibrant fodder crop, it has a potential to provide balanced diet to livestock and sustain under wide range of environmental condition.

Animal husbandry plays an important role in Indian economy. It gives livelihood to 2/3rd of rural population. In rural areas main income for the farmers comes from livestock rearing. India has largest livestock population of about 512.06 million (GOI, 2012). Even though India ranks first in livestock population the entire feed requirement is met by crop residues. An estimate revealed that fodder requirement in India is 883.95 Mt of green fodder and 583.66 Mt of dry fodder where as production is only 664.73 Mt of green fodder and 355.93 Mt of dry fodder (Yadav *et al.*, 2017). Presently there is decline in the availability of fodder as the area under fodder cultivation is declining. Currently India is facing shortage of 64% feeds, 61% green fodder and 22% dry crop residues. There is a huge gap between demand and supply (Dagar, 2017).

In Kerala livestock sector contributes 27.6 per cent to the agriculture GDP. Feed resource available from agriculture roughly meets 40 per cent of requirement. Increased crossbreeding dairy animal demand for feed and fodder is further increased (NDDB, 2016). To reduce the demand and supply gap, development of high yielding fodder crops through breeding techniques is very much essential.

Rice bean is useful for livestock feeding. The vegetative parts can be fed fresh or made into hay and the seeds are used as fodder (Chaudhuri *et al.*, 1981). Foliage of rice bean is of high value nutritive animal fodder with high amount of protein. Therefore, being an important source of protein it plays an important role in dairy and meat production (Kujur *et al.*, 2017).

To meet the reduced availability of fodder during the two scarcity periods, that is April-June and November-December, rice bean varieties can be successfully grown (Mukherjee *et al*., 1980). Rice bean is one of most important leguminous crop known for its remarkable drought tolerance and it is emerging as a high class nutritious animal fodder which is known to increase the milk production in livestock (Chatterjee and Das, 1989). Rice bean is an important fodder legume grown in diversified climate for diversified usage. Rice bean as fodder at vegetative stage contains high amount of protein (14-19 per cent) which is at par with cowpea and black gram (Dash, 2013).

At present there is urgent need to meet the demand of increasing number of livestock and also enhance their productivity for which availability of feed resources have to be increased. Almost all the grasslands and grazing areas are devoid of quality legumes in enough quantity. To enhance the production and productivity of good quality fodder and in order make dairying economically attractive, production and productivity of milk has to be increased. This is possible only by making available good quality feed and fodder in adequate quantity. There is tremendous pressure of livestock on available total feed and fodder, as land available for fodder production has been decreasing. The demand will reach to 1012 Mt of green fodder and 631 Mt of dry forage by 2050 (IGFRI, 2015).

Rice bean is a multipurpose fodder legume, it is a neglected minor crop which attracted very little research to asses genetic diversity, assessment of variability and development of high yielding varieties is very important in order to effectively utilize this multipurpose legume. With this vision present study was carried out to asses variability present in rice bean genotypes. The main objective of this investigation was

- To identify high yielding superior genotypes of rice bean (*Vigna umbellata* (Thumb) for fodder yield and quality.
- To find genetic variability among rice bean germplasm (Coefficient of variation, heritability and genetic advance)
- To study correlation among different characters.
- To study direct and indirect effect of quantitative character on fodder yield of Rice bean *(Vigna umbellata* (Thunb).

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Rice bean belongs to kingdom-Plantae, Order-Fabales, Family-Fabaceae, Sub-family-Faboideae, Genus- *Vigna,* Species- *umbellata*. Its common names are bammbo bean, bean rice, climbing mountain bean, crab eye bean, anipay, frijol arroz and gai-kalai. Rice bean is proved to be better than other leguminous fodders due to its high yielding, high protein content and tolerance to high and low moisture stress. It can be used as green manure, cover crop, living fence and biological barrier.It can thrive well under adverse climatic conditions, including drought, water logging and other soils.

Rice bean is a highly nutritious, palatable fodder. Nutritionally richer than cowpea and black gram, it contain 24.0% dry matter, 14.5% crude protein, 32.1% crude fibre, 1.0% fat, 1.2% calcium and 0.4% phosphorous.

2.1 GROWTH, QUALITY AND YIELD ATTRIBUTES FODDER RICE BEAN

2.1.1Biometric characters

2.1.1.1 Days to flowering

Gupta (2016) conducted an experiment to study genetic divergence among fifty rice bean genotypes and revealed that genotype RRB-12 has taken least number of days to attain 50% flowering, RRB-104 was found to flower late (71 days).

Genetic analysis study by Jharia (2007) in rice bean(*Vigna umbellata* (Thumb.) reported that days to 50% flowering was found to be maximum for the genotypes K-A (154 days) and KRB-167(149 days) , where as genotypes BFRB-8, JRB-6, BFRB-9, BFRB-10 and BFRB-5 had taken minimum number of days to reach 50% flowering.

Genetic analysis in fodder cowpea to study the variability among nine distinct lines of fodder cowpea (Maan, 2014) revealed that number of days taken to first flowering was ranging from 34 to 50 days, BCM 8 was the earliest to flower (34 days) and CL 367 was late to flower (50 days).

Days to 50% flowering varies from 46.33 days to 106.66 days in ten fodder oat varieties (Bakhsh *et al*., 2007). Days to 50% flowering varies from 46.333 days to 106.667 days in rice bean (Gupta 2016).

2.1.1.2 Plant height

An experiment conducted by Gupta (2016) to study divergence among fifty rice bean genotypes revealed that the genotype RRB-19 had highest plant height (76.40 cm) followed by RRB-13 (75.75 cm), genotype RRB-131 had minimum value (33.25 cm).

Jharia (2007) in rice bean reported that plant height ranges from 100-160.8 cm, genotype KFRB-8 recorded highest plant height of 160.8 cm whereas genotype k-1 recorded lowest plant height of 100cm.

Ahirwal (2011) recorded highest plant height for the genotypes JRB06-1-1 (122.23 cm), JRB07-28-2(120.33 cm) and JRB07-50-1 (114.70 cm) whereas minimum plant height was observed for JRB6 (47.28 cm), Bidhan-1-1 (52.87 cm) and JR06-11 (59.34 cm) genotypes of rice bean.

Mohapatra (1973) recorded maximum plant height of 45.4 cm in soya bean in a study conducted at Sunabeda region of Orissa. Borah (1994) conducted an experiment in Shillongani region of Assam, genotype RBL-3 was recorded maximum plant height of 77cm.

Rice bean variety RBL-7 recorded maximum plant height of 32.23 cm in a study conducted at Nagaland region (Seyie *et al*., 2006). Varietal trial conducted by AICRP on forage crops (2013) revealed that the genotype JRB-17 recorded maximum plant height of 148 cm.

Rice bean variety Bidhan-2 recorded maximum plant height of 135 cm in varietal trial conducted by AICRP on forage crops (2015). In rice bean range of plant height obtained between 30.100cm to 196.067cm (Gupta, 2016).

A study conducted by Maan (2014) in nine distinct lines of fodder cowpea showed that vine length varied from 45.00 to 92.67 cm among all the lines, C 74 showed maximum vine length of (92.67 cm) whereas in BCM 8 showed minimum vine length (45.00 cm).

Genetic divergence study in fodder oat revealed range of plant height obtained between 30.100cm to 196.067cm (Bakhsh *et al*. 2007).

2.1.1.3 Number of branches per plant

Gupta (2016) in a study conducted with rice bean genotypes revealed that number of branches varies from 1.9 to 11.36. Divergence study among fifty rice bean genotypes revealed that maximum number of branches per plant (4.5) was observed in the genotype RRB-17, minimum in LRB-554 (2.00), LRB-127 (2.00), RRB-18(2.00), RRB-524(2.00), LRB-131(2.00), LRB-283 (2.00) and NDRB-2 (2.00).

In rice bean number of branches varied from 2.23 to 13.41. Maximum number of branches was recorded for the genotypes JR07-13(13.41), JR07-1 (12.03) and JRB1-1 (10.50). Genotypes JR07-4, JRB06 (2.70) and JR06-114 (3.20) recorded minimum number of branches per plant (Ahirwal , 2011)

Jharia (2007) reported that maximum number of branches per plant was recorded in JRB-6 (3.66) and minimum in KRB-235 (2.3) genotypes of rice bean.

Evaluation of nine distinct lines of cowpea by Maan (2014) showed that branches per plant varied from 5 to 10 branches, the highest number of branches were observed in FOS 1, The minimum number of branches per plant were observed in BCM 8.

In an experiment conducted by Bakhsh *et al*. (2007) in fodder oat revealed that genotype Cuscade, Scott, Local D. I. Khan, Local Rawalpindi, No. 677 and Australian have highest number of tillers per plant similarly Jasper (4.67), S-2000 (5.22) and Kent (7.22) produces minimum number of tillers per plant.

2.1.1.4 Number of leaves per plant

Ahirwal (2011) conducted an experiment to study variability for qualitative and quantitative characters among 75 genotypes of rice bean in JNKV Jabalpur and reported that number of leaves varies from 32.47 to 88.27, genotype JRB07-43-1 (88.27) recorded maximum number of leaves followed by JRB35-2(87.54) and

JRB35-1 (85.30). Variety JRB6 (32.47) recorded minimum number of leaves followed by KRB86 (32.97) and JRB07-43-2 (35.77).

Number of leaves per plant varied from 14.26 to 39.83, genotype JRB-5 recorded highest number of leaves per plant whereas genotype BFRB-5 recorded lowest number of leaves per plant (Gupta, 2016).

In a study conducted by Maan (2014), among nine distinct lines of fodder cowpea showed that number of leaves per plant varied from 141 to 277, maximum number of leaves were observed in FOS 1, minimum number of leaves were present in BCM 8.

2.1.1.5 Leaf stem ratio

Bidhan-1 variety of fodder rice bean recorded maximum leaf stem ratio of 0.80 (AICRP on forage crops, 2003). Maximum leaf stem ratio of 0.80 was recorded for the genotype JRB-17 (AICRP on forage crops, 2013). Varietal evaluation conducted by AICRP on forage crops and utilization revealed that the rice bean variety Bidhan-2 recorded maximum leaf stem ratio of 0.87 (AICRP on forage crops, 2015).

In rice bean highest value of leaf stem ratio was observed for the genotype JRB07-28-2(1.27), JR06-1-1 (1.18) and JR06-2 (1.12). Lowest was observed for the genotypes JRB07-43-3(0.27), JRB07-43-2(0.31) and KRB (0.35). (Ahirwal , 2011)

Highest leaf stem ratio of 1.51 was obtained for the genotype JRB-5 whereas lowest 0.65 was obtained for the genotype KRB-235 in rice bean (Jharia, 2007).

A study conducted by Aswathi (2016) in rice bean showed that variety KBR-1 recorded highest leaf: stem ratio (0.81) and varieties Bidhan-1 and Bidhan-2 recorded minimum leaf stem ratio of 0.53. In rice bean values of leaf stem ratio varies between 0.160 to 1.350 (Gupta 2016).

According to Maan (2014) the leaf: stem showed the range of 0.42 to 0.61 cm among nine distinct lines of fodder cowpea, maximum leaf: stem ratio was observed in CL 391 whereas minimum leaf: stem ratio was observed in FOS 1.

A study conducted by Singh *et al*. (1979) in semi arid regions of Rajasthan in rice bean infer that variety JC-1 recorded maximum leaf to stem ratio of 2.11.

2.1.2 **Physiological character**

2.1.2.1 Leaf area index

A study conducted in rice bean revealed that genotype BFRB-71 recorded highest leaf area of 89.45 cm^2 followed by JRB07-43-1(84.30 cm^2) and JRB07-33 (82.43 cm^2). Minimum leaf area was recorded from the genotypes BFRB8-1-1 (42.31 cm^2), JRB6 (44.90 cm^2) and KRB128 (47.73cm^2) (Ahirwal , 2011). Leaf area index of 4.04 was recorded for fodder rice bean (Aswathi, 2016).

Maximum leaf area was obtained for the genotypes KRB-128 (57.16 cm^2), JRB-5(53.46 cm^2) and KRB-19 (51.31 cm^2). Lowest was obtained for the genotypes BFRB-7(32.73 cm^2), KRB-102 (34.30 cm^2) and JRB-6 (35.58 cm^2) (Jharia 2007).

In an experiment conducted by Bakhsh *et al*. (2007) in oat varieties showed that leaf area ranged between 79.13 cm^2 156.40 cm^2.

2.1.3 **Quality attributes**

2.1.3.1 Crude protein and Crude fibre

Rice bean variety KHRB-1 recorded highest crude protein of 14.30 % (Rudragouda and Angadi, 2002).

In rice bean highest crude protein was recorded in the genotype BFRB-9 (18.20%), lowest value was recorded in the genotype KRB-128. Maximum crude fibre of 39.90 was recorded in the genotype BFRB-3, minimum for the genotype BFRB-17 in a study conducted by Jharia (2007).

Katoch *et al.* (2007) conducted an experiment in rice bean in Himachal pradesh, result showed that genotype IC137190 contains highest crude protein content of 18.92%, genotype C137188 contains lowest crude protein content of 13.59%.

A study conducted by George (2018) in college of Agriculture, Vellayani, revealed that fodder horse gram genotype IC-22791 recorded maximum crude fibre content of 32.15% whereas genotype IC-22794 recorded least crude fibre content of 24.40%.

Maan (2014) reported that the range for crude protein content varied from 13.65 to 16.80 among nine distinct lines of fodder cowpea, The maximum crude protein content was observed in C 88 (16.80%) followed by CL 398 (16.10%) and the minimum was observed in CL 391 (13.65%) followed by BCM 8 (13.67%).

Thaware *et al*., (1992) showed highest crude protein was observed in the UPC-9805 variety of fodder cowpea. In an experiment conducted by Radhakrishna *et al.* (2007) in hedge lucerne (*Desmanthus virgatus* (L.) Wild) showed that mean crude protein and crude fibre content were 15.20% and 19.77% respectively.

Sorghum variety SPV 462 recorded highest crude protein percentage of 7.08% which was on par with other varieties Phule Revati, CSV 19 SS, Pant Chari 5 and CSV 15. Genotype HJ 513 recorded highest crude fibre percentage of 33.11%, lowest in CSV 27 (22.71%) (Singh and Chauhan, 2017).

2.1.4 Yield attributes

2.1.4.1 Green fodder yield

Green fodder yield ranges between 0.005 quintal to 0.074 quintal in rice bean genotypes (Gupta, 2016). A varietal trial conducted by AICRP on forage crops and utilization (2006) revealed that rice bean variety KRB-7 recorded maximum green fodder yield of 259.8 q ha $^{-1.}$Fodder rice bean genotype KBR-1 recorded highest green fodder yield of 11.3 t ha^{-1} (Aswathi, 2016).

In rice bean maximum green fodder yield per plant was observed for the genotype JRB-6 (167.60G) and KRB-19 (165.63g), minimum for the genotypes K-1(81.20g) (Jharia 2007).

Variability study conducted by Maan (2014) among nine distinct lines of cowpea showed that fodder yield showed the range of 6.00 to 8.33 kg/plot, The maximum green fodder yield was observed in 85-5E (8.33 kg/plot), The minimum green fodder yield was observed in C 88 (6.00 kg/plot).

Kumar *et al*. (2017) conducted an experiment to study genetic diversity among twenty elite fodder cowpea genotypes, result revealed that GFC-2 showed maximum green fodder yield per plant followed by EC 3941-1, IC528491, GFC-4 and TV92-2.

In an experiment conducted by Chaudhary *et al.* (2018) to study variability for fodder yield among 34 sorghum genotypes revealed that cultivar HJ-513 recorded maximum fodder yield.

In an experiment to evaluate berseem clover population by Zeinab *et al*. (2015) revealed that variety Khadarawy recorded maximum green fodder yield (72.5 tons) and dry fodder yield (9.79 tons). Character fresh yield shows high heritability.

A study by Thaware *et al*., (1992) in fodder cowpea showed maximum green fodder yield recorded in the variety UPS-9021. In a study conducted by (Bakhsh *et al*. 2007) in ten genotypes of fodder oat recorded green fodder yield ranges between 0.005 quintal to 0.074 quintal.

In a study conducted by Singh and Chauhan (2017) revealed significant difference for green fodder yield among all the varieties studied. Sweet sorghum variety CSH 22 SS showed highest green fodder yield (71.28 t/ ha) which was on par with the other varieties HC 308 and CSV 21F.

2.1.4.2 Dry matter yield

In rice bean dry matter yield varies between 0.116 quintal to 1.495 quintal (Gupta 2016).

A study in fodder rice bean by Jharia (2007) revealed that dry fodder yield per plant was maximum for the genotype JRB-6 (32.33), KRB 239(29.84) and BFRB-9 (29.42). Genotypes KRB-86(17.79) and BFRB-5 (17.93) recorded lowest value.

Nine distinct lines were assessed for forage and quality traits in cowpea, it was found that dry matter yield per plot varied from 0.90 to 1.27 kg/plot, The maximum dry matter yield was observed in 85-5E (1.27 kg/plot) followed by C 74 (1.11 kg/plot), CL 367 (1.08 kg/plot), CL 391 (1.07 kg/plot) and CL 396 (1.03 kg/plot). The minimum dry matter yield per plot was observed in C 88 (0.90 kg/plot) (Maan 2014).

Dry matter yield varies between 0.116 quintal to 1.495 quintal among ten genotypes of fodder oat (Bakhsh *et al*. 2007).

2.2 VARIABILITY, HERITABILITY AND GENETIC ADVANCE

Success of any plant breeding program is dependent on the presence of variability among available germplasm lines. Presence of variability is very important to plant breeder in order to perform selection in variable plant population. Variability is divided into two types genotypic variability and phenotypic variability. Genotypic variability comprises of additive and non-additive components. Heritability is defined as proportion of total variability due to genetic cause or ratio of genetic variance to total variance.

Genetic gain is the product of its heritability, phenotypic standard deviation (σ_p) and selection differential (Burton, 1952). Heritability and genetic advance is very important in predicting the effectiveness of selection. Genotypic and phenotypic co-efficient of variation, heritability and genetic advance estimates for different characters are very important for the breeder to apply appropriate breeding methodology in the crop improvement program.

Barthakur *et al*. (2001) conducted an experiment to study performance of rice bean (*Vigna umbellata*) genotypes in mid-altitude conditions of Meghalaya. Analysis of variance showed highly significant variation for dry fodder yield, dry matter production and green fodder yield.

Variability study in rice bean (Dodake and Dahat, 2011) revealed significant variation among 50 genotypes for all the twelve characters under investigation.

Divergence studies in rice bean (Gupta, 2016) revealed significant variation for all the fifteen characters studied and revealed that phenotypic coefficient of variation is more than genotypic co-efficient of variation, high phenotypic and genotypic co-efficient of variation was observed for the characters green fodder yield(69.348%), dry matter yield(59.380%) and leaf: stem ratio(43.572%). Minimum value was observed for the trait days to maturity (16.364%).

Lakshmana *et al*. (2010) conducted an experiment to study diversity among twelve traits in rice bean, they observed that maximum phenotypic coefficient variation (PCV) and minimum genotypic coefficient of variation (GCV) for all the characters. The GCV and PCV values are maximum for the days to 50 per cent flowering and harvest index whereas broad sense heritability high for all the characters. Genetic advance was found to be high for days to 50 per cent flowering, harvest index and number of branches per plant.

An experiment conducted by Pandey *et al*. (2015) to study co-efficient of variation, heritability, genetic advance and variability for ricebean (*Vigna umbellata* (Thunb.) genotypes under mid hill conditions of Uttarakhand showed that phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the twelve characters studied.

An experiment in rice bean revealed maximum heritability for the character green forage yield (99.698%), plant height (99.572), dry matter yield (98.975%), leaf: stem ratio (98.333%), days to 50% flowering (98.250%) and number of primary branches (93.416%). Genetic advance percentage was recorded high for the traits green fodder yield (142.426%), dry matter yield (121.806%), leaf: stem ratio (88.260%), plant height (81.896%), number of primary branches (65.621%), days to 50% flowering(36.653) and days to maturity (32.866%) (Gupta, 2016).

Gerrano *et al*. (2015) conducted an experiment to study variability among twenty-five genotypes of cowpea revealed that the phenotypic variance was relatively higher than the genetic variance for all morphological quantitative characters studied. This inferred that there was a larger environmental influence on genotypes during the growing period relative to genetic factors. In general, it can be seen that there were higher phenotypic coefficients of variation compared with the genetic coefficients of variation. This implies that the variation observed in this study was mainly due to environmental factors rather than genetic factor.

Variability study by Kumar *et al*., (1997) in thirty mutant lines of rice bean showed existence of variability for plant height and number of branches per plant.

Devine *et al*., (2002) in fodder soya bean revealed existence of significant variability for leaf area index, plant height, days to harvest, days to maturity, green fodder yield, crude protein percent and neutral detergent fibre.

Cho *et al*., (2003) found significant variation for number of branches per plant and crude protein content in forage soya bean genotypes.

Sarkar and Mukerjee (2007) conducted an experiment in eighteen genotypes of rice bean and showed that heritability is high for the characters plant height (94.9%), days to 50% flowering (95.70%), and days to maturity (93.70%). All most all the characters showed considerable moderate to high heritability except number of branches per plant.

A study conducted by Johnson (1987) in forage cowpea showed significant difference for crude protein content, neutral detergent fibre and lignin content.

An experiment in twenty five varieties of fodder cowpea (Riquib and Patnaik, 1990) showed maximum PCV and GCV for plant height at maturity, green fodder yield and terminal leaflet area.

Kapoor and Batra (2014) conducted an experiment to study Genetic variability and association studies among twelve genotypes in maize (*Zea mays* L.) for quality traits and green fodder yield and concluded that genotypes differ significantly for all the characters. Characters such as plant height, leaf length, leaf width, stem girth, number of leaves, crude protein, acid detergent fibre, dry matter yield and green fodder yield indicating the predominance of additive effects hence they exhibit maximum heritability and genetic advance. The phenotypic coefficients of variation (PCV) estimate were maximum than their corresponding genotypic coefficient of variation (GCV) values thereby infer the environmental influence.

Rony *et al.* (2019) conducted an experiment to study genetic variability for yield and related characters in lab lab bean and the result revealed existence of considerable variability for all the characters studied.

In a study conducted by Medhi *et al*. (1980) showed significant variation for all the 10 characters studied in *Vigna radiata.* Genotypic and phenotypic coefficient of variability was found to be small for all the characters studied.

Analysis of variance by Lesly and Uma (2006) showed significant difference among all the genotypes for all the characters.

In experiment by Adewale *et al*. (2011) maximum phenotypic coefficient of variation and minimum genotypic coefficient of variation for all the characters were recorded cowpea.

Analysis of variance in moth bean showed presence of variability among all the characters studied. Characters such as plant height, primary branches per plant, secondary branches per plant, showed high PCV and GCV. Traits such as days to 50 per cent flowering, plant height, secondary branches per plant showed maximum heritability and genetic advance (Yogeesh, *et al.* 1924)

Santhosha *et al*. (2016) conducted an experiment to study variability in cluster bean revealed maximum variation for number of branches and plant spread. Heritability and genetic advance was found to be high for the characters number of branches, plant height, stem girth and plant spread.

In a study conducted by Sen *et al*. (2019) to evaluate the genetic variability in sixteen varieties of fodder sorghum revealed significant difference for all the characters studied, maximum phenotypic and genotypic co-efficient of variation were recorded for the traits plant height, stem girth, leaf: stem ratio and green fodder yield where as traits like leaf length, days to 50% flowering, leaf bredth, leaf area, leaf: stem ratio, protein content and green fodder yield per plant were exhibited high heritability and genetic advance.

Kour and Pradhan (2016) conducted experiment to study variability heritability and genetic advance among 40 genotypes for fifteen traits in fodder sorghum, analysis of variance showed that all the genotypes differ significantly for all the characters studied. PCV, GCV, heritability and genetic advance were found to be high for the characters like leaf:stem ratio, number of leaves per plant, green fodder yield, stem girth and dry matter yield.

Malarvizhi, *et al*. (2005) conducted an experiment to study genetic variability among fifty cowpea genotypes revealed that, all the 60 genotypes varied significantly for the characters plant height, number of branches per plant, number of leaves per plant, leaflet length, leaflet width, stem thickness, dry matter yield, green fodder yield, dry weight of leaves, dry weight of stem, leaf: stem ratio and crude protein. Characters number of branches per plant, number of leaves per plant, dry weight of leaves, dry weight of stem, dry matter yield and plant height had showed additive genetic effects hence heritability and genetic advance was found to be high for these characters.

A study conducted by Chaudhary *et al*. (2018) in fodder sorghum to investigate variability for fodder yield component among 34 genotypes revealed significant difference for all the characters investigated. Characters, number of leaves per plant, leaf stem ratio and green fodder yield showed highest genotypic coefficient of variation (GCV) and phenotypic coefficient variation (PCV), whereas characters such as plant height, leaf length, leaf area, number of leaves per plant, leaf stem ratio and green fodder yield exhibited predominance of additive gene effects so estimates of heritability and genetic advance were high for these characters.

Sharma *et al*. (2017) conducted an experiment to study Genetic variability in cowpea [*Vigna unguiculata* (L.) Walp.] germplasm lines. Characters plant height and primary branches per plant showed maximum GCV and PCV. Heritability and genetic gain were found to be high for the characters plant height, primary branches per plant and harvest index.

A study conducted in fodder soya bean by Thakur (1990) showed that PCV and GCV were maximum for the characters leaf area per plant, plant height and number of branches and minimum for the character days to harvest.

Variability study in thirty four cowpea genotypes revealed maximum PCV and GCV for leaf area and leaf stem ratio (Backiyarani and Nadarajan, 1995).

Mishra *et al*. (1995) conducted genetic variability study in ten genotypes of rice bean and observed maximum genotypic co-efficient for all the characters.

2.3 CORRELATION AND PATH ANALYSIS

To maximize genetic potential of any crop interrelation of the yield and its components is very important. Correlation study helps to know about degree and direction of yield with its components and also among various components, some components affect yield directly while others contribute indirectly. Correlation co-efficient does not gives an idea about inter-relationship between various characters which are related to yield. So it is very important to give proper weightage to character in deciding suitable criteria for genetic improvement, which can be done through path co-efficient analysis, it is the ratio of standard deviation of the effect due to a given cause to the total standard deviation of the effect. This method was suggested by Dewey and Lu (1959) for portioning the correlation co-efficient into direct and indirect causes.

Character association study conducted by Kujur *et al*. (2017) among components of green fodder yield in rice bean revealed that green fodder yield per plant was significantly and positively associated with green fodder yield per day, number of leaves per plant, number of branches per plant, crude protein yield per plant, crude protein yield per plant per day, dry matter yield per plant, dry matter yield per plant per day, leaf stem ratio and plant height at both genotypic and phenotypic levels.

Path coefficient analysis studied by Kujur *et al*. (2017) revealed that green fodder yield per plant per day has highest direct effect and significant positive correlation towards yield. Other traits, crude protein yield per plant, dry matter yield per plant per day, days to 50% flowering, days to flower initiation and plant height were also found to be important fodder yield indicators in rice bean.

Navaselvakkumaran *et al*. (2019) conducted an experiment to study interrelationship and path coefficient analysis of fodder yield and yield component traits in fodder cowpea (*Vigna ungiculata* L. Walp), result revealed that traits such as number of primary branches per plant, number of leaves per plant and leaf area exhibited significant positive correlation towards green fodder yield per plant as well as dry matter yield per plant. The highest positive direct effect of leaf area and the highest positive indirect effects of number of leaves per plant and dry matter yield per plant via leaf area would contribute more towards increasing green fodder yield per plant.

Correlation study in berseem clover (Zeinab *et al*. 2015) showed that characters such as dry yield, fresh yield and leaf: stem ratio exhibit positive correlation. In a study conducted by Gupta (2016) in rice bean revealed that plant height exhibit direct positive correlation with green fodder yield and negative correlation with leaf: stem ratio. Number of primary branches per plant exhibited positive correlation with dry matter yield and green forage yield, negative correlation with leaf: stem ratio.

Path analysis by Zeinab *et al*. (2015) in berseem clover revealed indirect effect of leaf: stem ratio through fresh yield on dry yield, protein through fresh yield and crude fibre through leaf: stem ratio and direct effect on fresh yield and leaf: stem ratio.

In a study conducted by Deepthi *et al*. (2013) in hedge lucerne (*Desmanthus virgatus*(L.) Wild) revealed that green fodder yield was significantly and positively correlated with number of branches per plant, leaf to stem ratio and dry matter yield per plant. Path analysis showed high positive direct effect of dry matter yield on green fodder yield per plant, number of branches per plant, plant height and leaf: stem ratio.

Correlation study by Pol *et al*., (2001) for morphological, physiological and yield components in rice bean revealed plant height, number of branches per plant, number of leaves, leaf area, leaf dry weight per plant, total dry matter per plant, 100 grain weight, harvest index and leaf area index were significantly and positively correlated with yield.

A study by Kumar and Mishra (1994) in fifty varieties of fodder cowpea revealed that dry matter yield and plant height had direct positive effect on green fodder yield.

Path co-efficient analysis by Kohli and Agarwal (2002) in twenty six cowpea genotypes observed that stem fresh weight stem weight had direct positive effect on green fodder yield. Characters like number of primary branches, number of secondary branches, stem diameter, petiole length and number of nodes had indirect effect on green fodder yield through stem weight.

Borah and Khan (1999) in sixty genotypes of fodder cowpea reported that dry matter yield, leaf:stem ratio and plant height exhibit direct positive effect on green fodder yield whereas characters like number of leaves , leaflet width, days to 50% flowering, leaf dry weight and stem dry weight had indirect effect on green fodder yield through dry matter yield.

A study by Mehta *et al*., (2007) in eight varieties of fodder soya bean revealed that number of branches, plant height and crude protein content had positive direct effect on green fodder yield. Days to harvest, leaf stem ratio, number of nodules, and dry weight of nodules showed positive negative effect on green fodder yield.

2.4 CLUSTER ANALYSIS

Study of genetic diversity is important to identify genotype with increased yield, wider adaptability and desirable qualities. Genetic divergence is used to find out genetic distance between cultivars. D2 statistics suggested by Rao (1952) gives idea about genetic distance between various genotypes.

Kujur *et al*. (2017) conducted an experiment to study genetic divergence among eighty-five genotypes of rice bean, On the basis of D^2 values, the 85 genotypes were grouped into six clusters following Tocher's method, which resulted in six clusters having maximum inter-cluster distance between cluster II and VI and least between clusters I and V. Maximum intra-cluster distance was exhibited by cluster VI followed by cluster IV.

D^2 analysis in 50 genotypes of rice bean into eight clusters, cluster I, II, III, IV, V, VI, VII and VIII includes 9, 13, 10, 8, 6, 10 and 5 genotypes respectively, maximum cluster mean was observed for the cluster VIII and lowest for the cluster V(Gupta, 2016).

Yogeesh, *et al.* (2016) conducted an experiment to study morphological and genetic variability in 121 genotypes of moth bean and grouped into eight clusters. Maximum numbers of genotypes (90) were found in the cluster I and cluster III contains 25 genotypes. Maximum intra-cluster distance was found in the cluster III. Cluster III and VI cluster, IV and VIII showed maximum inter cluster distance.

Genetic divergence studies in fodder cowpea using D^2 statistics (Praveena, 2019) grouped 30 genotypes of cowpea into eleven clusters, cluster I and cluster II contains ten and five genotypes respectively cluster III and cluster IV have four genotypes each, remaining seven genotypes have one genotype each. Cluster IV (146.57) showed highest intra-cluster D_2 value followed by cluster I (127.52), cluster II (101.49) and cluster III (55.47). Cluster VIII and cluster X (1559.98), cluster VIII and cluster XI (1480.33), cluster VIII cluster II (1367.65), and cluster VIII and cluster IV (1309.08) showed maximum inter-cluster D2 values among genotypes. Cluster XI and cluster IX (160.10), cluster I and cluster III (164.51), cluster XI and cluster IV (167.47) showed minimum inter-cluster D_2 values among genotypes.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study on “Genetic analysis in fodder rice bean (*Vigna umbellata* (Thunb.) for yield and quality” was carried out at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, during 2018-2020 to identify high yielding superior fodder genotype for yield and quality.

The materials and methods used in the study are listed below.

3.1 EXPERIMENTAL SITE

The present study was conducted at College of Agriculture, Vellayani, situated at 8°5’ N latitude and at an altitude of 29 m above mean sea level. Predominant soil type of the experimental site was sandy loam.

3.2 EXPERIMENTAL DESIGN

The experiment was laid out in Randomized Block Design (RBD) with thirty treatments and three replications. The plot size of $3m^2$ was followed in the field experiment.

3.3 EXPERIMENTAL MATERIAL

Thirty genotypes of rice bean collected from NBPGR regional station Phagli, Shimla were evaluated for fodder yield and quality. The list of thirty genotypes of rice bean (*vigna umbellata* (Thunb.) are presented in Table1.

3.4 CULTURAL OPERATIONS

The land was prepared thoroughly by ploughing and levelling. The seeds of each genotypes collected were soaked overnight and sown at a spacing of 30cm between rows and 10 cm between plants.

Table 1. List of 30 rice bean (*vigna umbellata* (Thunb.) accessions used in the present investigation.

Sl. No.	Treatment name	Accession name	Source
1	T1	EC16136	NBPGR Regional station, Phagli, Shimla
2	T2	EC18260	NBPGR Regional station, Phagli, Shimla
3	T3	EC98452	NBPGR Regional station, Phagli, Shimla
4	T4	IC2567	NBPGR Regional station, Phagli, Shimla
5	T5	IC8565-3	NBPGR Regional station, Phagli, Shimla
6	T6	IC15640	NBPGR Regional station, Phagli, Shimla
7	T7	IC18456	NBPGR Regional station, Phagli, Shimla
8	T8	IC18465	NBPGR Regional station, Phagli, Shimla
9	T9	IC18553	NBPGR Regional station, Phagli, Shimla
10	T10	IC19338	NBPGR Regional station, Phagli, Shimla
11	T11	IC341986	NBPGR Regional station, Phagli, Shimla
12	T12	IC341991	NBPGR Regional station, Phagli, Shimla
13	T13	IC341997	NBPGR Regional station, Phagli, Shimla
14	T14	IC341998	NBPGR Regional station, Phagli, Shimla
15	T15	IC469192	NBPGR Regional station, Phagli, Shimla
16	T16	IC469195	NBPGR Regional station, Phagli, Shimla
17	T17	IC521114	NBPGR Regional station, Phagli, Shimla
18	T18	IC521115	NBPGR Regional station, Phagli, Shimla
19	T19	IC521116	NBPGR Regional station, Phagli, Shimla
20	T20	IC521119	NBPGR Regional station, Phagli, Shimla
21	T21	IC521122	NBPGR Regional station, Phagli, Shimla
22	T22	IC521123	NBPGR Regional station, Phagli, Shimla
23	T23	IC521128	NBPGR Regional station, Phagli, Shimla
24	T24	IC521134	NBPGR Regional station, Phagli, Shimla
25	T25	IC521143	NBPGR Regional station, Phagli, Shimla
26	T26	IC521145	NBPGR Regional station, Phagli, Shimla
27	T27	IC521149	NBPGR Regional station, Phagli, Shimla
28	T28	IC521150	NBPGR Regional station, Phagli, Shimla
29	T29	IC521152	NBPGR Regional station, Phagli, Shimla
30	T30	IC521350	NBPGR Regional station, Phagli, Shimla

Plate 1. Field view of the experiment (10DAS)

Plate 1(Continued). Field view of the experiment (20DAS)

Plate 1(Continued). Field view of experiment (30DAS)

Plate 1(Continued). Field view of experiment (40DAS)

Plate1 (Continued). Field view of experiment (50 DAS)

3.5 RECORDING OF OBSERVATIONS

Observations were taken from five randomly selected plants in each treatment at the time of harvest. The mean values of five plants were considered for statistical analysis. The observations were taken on the following characters at 50 per cent flowering *i.e* at the time of harvest.

3.5.1 Biometric observations

3.5.1.1 Days to First Flowering

When the first plant of the genotype flowered, the date was recorded, and the number of days was calculated from the date of sowing.

3.5.1.2 Days to 50 per cent Flowering

When 50 per cent plants of a genotype flowered, the date was recorded, and the number of days was calculated from the date of sowing .

3.5.1.3 Vine length

The height of the plant was measured from base of the plant to the tip of the vine at the time of harvest using measuring scale and their mean values were expressed in centimetre.

3.5.1.4 Number of Branches per Plant

The total number of branches arising from the main stem was counted at the time of harvest.

3.5.1.5 Number of leaves per plant

Total numbers of leaves produced per plants were counted at the time of harvest.

3.5.1.6 Leaf Stem ratio

After taking dry weight of leaf and stem, leaf stem ratio was calculated by dividing leaf dry weight by stem dry weight.

3.5.2 Physiological characters

3.5.2.1 Leaf area index

The leaf area was measured from the observational plants of each plot. Representative leaves were collected and leaf area was measured by multiplying length and breadth of a leaf with a constant factor 0.65. Total leaf area was worked out by multiplying the leaf area of selected leaves and number of leaves per plant. The leaf area index (LAI) was calculated using the formula given by Watson (1952).

$$\text{LAI} = \frac{\text{Leaf area of plant}}{\text{Ground area occupied}}$$

3.5.3 Quality aspects

3.5.3.1 Crude protein content

Protein content was calculated by multiplying nitrogen content of the plant by the factor 6.25 and expressed in percentage.

CP (%) = %N x 6.25

3.5.3.2 Crude fibre content

Crude fibre content was determined by AOAC method (AOAC 1975), and expressed in percentage (%).

3.5.4 Yield attributes

3.5.4.1 Leaf fresh weight per plant

The plants were cut at the base, leaves were plucked from the plant at the time of harvest and fresh weight of leaves was recorded.

3.5.4.2 Stem fresh weight per plant

After plucking the leaves remaining stem fresh weight was recorded at the time of harvest.

3.5.4.3 Green fodder yield

The crop was harvested at the 50 per cent flowering stage. The fresh weight of plant in each plot was recorded. The total green fodder yield was calculated and expressed in t ha^{-1}.

3.5.4.4 Leaf dry weight per plant

The separated leaves were shade dried first, then oven dried at $70^{\circ} \pm 5^{\circ}$ till constant weight was reached, then the dry weight of the leaves was recorded.

3.5.4.5 Stem dry weight per plant

Stems of the plants were shade dried followed by oven drying at $70^{\circ} \pm 5^{\circ}$ till constant weight was attained. Then the dry weight of the stem was recorded.

3.5.4.6 Dry fodder yield

The plants samples collected from each harvest were shade dried and later oven dried at $70^{\circ}C \pm 5^{\circ}$ till the samples attained a constant weight. The weight of these dried samples was taken and dry fodder yield was calculated and expressed in t ha^{-1}.

3.5.4.7 Dry matter production

At 50 per cent flowering stage five observational plants from each replication were uprooted. Shoot, leaves and roots were separated and dried to a constant weight at 70° C ± 5° in hot air oven till constant weight was attained. Weight of individual components were taken, sum of these total weight gave dry matter production.

3.5.4.8 Production efficiency

The crop was harvested when the crop reached 50 per cent flowering stage. The fresh weight of the plants in each plot was recorded and expressed in tons per hectare (t ha^{-1}). The fresh weight was divided by number of days to harvest to calculate the production efficiency and expressed in t $ha^{-1}day^{-1}$.

$$\text{Production efficiency} = \frac{\text{Green fodder yield}}{\text{Number of days taken to harvest}}$$

3.6 STATISTICAL ANALYSIS

The data recorded on different traits were subjected to the following statistical analysis.

1. Analysis of variance.
2. Estimation of genetic parameters viz., PCV, GCV, Heritability and Genetic Advance.
3. Cluster analysis.
4. Correlation analysis.
5. Path analysis.

3.6.1 Analysis of variance

3.6.1.1 Analysis in Randomized Block Design (RBD)

The randomized block design (RBD) was adopted with three replications. As per the method given by Panse and Sukhatme (1985) the analysis of variance was carried out.

Total variation for each character is portioned into variation due to genotype, blocks and error.

$$Y_{ij} = m + g_i + e_{ij}$$

Where. Y_{ij}= Phenotypic observation of i^{th} genotype in j^{th} replication

m = General mean

g_i = True effect of i^{th} genotype

r_j = True effect of j^{th} replication.

e_{ij}=Random error associated with i^{th} genotypes in j^{th} replication.

Based on above model analysis of Variance (ANOVA) was carried out for all the characters.

Source of variation	**Df**	**SS**	**MSS**	**F-ratio**
Replication	r-1	RSS	M_{sr}	M_{sr} / M_e
Genotypes	t-1	TSS	M_{st}	M_{st} / M_e
Error	(r-1) (t-1)	ESS	M_{se}	
Total	rt-1			

Where,

r = Number of replications

t = Number of treatments

M_{sr}= Mean sum of squares of replications

M_{st} = Mean sum of squares of treatments

M_{se}=Mean sum of squares of error

d.f = Degrees of freedom

The significance of mean sum of squares for each character was tested against the corresponding error degrees of freedom using ‘F’ test (Fisher and Yates, 1967).

Range, mean, standard error of mean, critical difference and co-efficient of variation were calculated to study components of variance among genotype.

Range = Highest value-Lowest value

Standard Error Mean, (SE (m)) = $(Mse/r)^{1/2}$

Where,

M_{se} =Error mean squares

r =Number of replications

Critical difference, C. D = S. E (d) x t

where,

Standard error, S.E(d) = $(^{Mse}/_{r})^{1/2}$

't' = t table value at error degrees of freedom

Co-efficient of variation, C.V = $(^{S.D}/_{\overline{X}})$ x 100

Where, S. D = Standard deviation of the population

$\overline{X}$ = Population mean

3.6.2 Estimation of Genetic parameters

3.6.2.1 Genetic components of variance

Phenotypic and genotypic components of variance were estimated for each character by equating expected value of mean square (MS) to the respective variance component (Jain, 1975).

Genotypic variance (V_G) $V_G = \frac{Mst - Mse}{r}$

Environmental variance (V_E) $V_E = M_{se}$

Phenotypic variance (V_p) $V_p = V_G + V_E$

3.6.2.2 Coefficient of variation

Genotypic, phenotypic and environmental Coefficient of variation were estimated from V_{P}, V_G and V_E. These values were expressed in percentage for each trait.

i. Genotypic coefficient of variation, GCV= $\sqrt{\frac{VG}{\bar{X}}}X\,100$

ii. Phenotypic coefficient of variation, PCV= $\sqrt{\frac{VP}{X}}X\,100$

iii. Environmental coefficient of variation= $\sqrt{\frac{VE}{X}}X\,100$

where X = Grand mean

Sivasubramanian and Menon (1973) reported following range of variation.

High: >20per cent

Medium: 10-20 per cent

Low :< 10 per cent

3.6.2.3 Broad sense Heritability

Ratio of genotypic variance to the phenotypic variance in the population and character expressed in percentage.

$$H^2 = \frac{VG}{VP}X100$$

Johnson *et al*., 1955 classified range of heritability estimation into following types.

High: >60 per cent

Medium: 30-60 per cent

Low:<30 per cent

3.6.2.4 Genetic advance

The expected genetic gain or improvement in the next generation by selecting superior genotype under certain amount of selection pressure. Genetic advance estimated by using Burton (1952) formula.

$$G\,A = K\sigma_{p.}\,h^2$$

h^2- heritability in broad sense

σ_p- Phenotypic standard deviation

K- Standardised selection differential which is expressed in terms of standard deviation units and its value vary with the intensity of selection. For present study value of K is 2.06.

3.6.2.5 Genetic advance as percent of mean

$$GAM = \frac{GA}{X} X100$$

GA= Genetic advance

X = Grand mean

Ranges of Genetic advance by Johnson *et al*., (1955).

High: >20 per cent

Medium: 10-20 per cent

Low: <10 per cent

3.6.3 ESTIMATION OF CORRELATION

Degree and direction of association between two variables refer the correlation. Genotypic and phenotypic correlations were calculated by using Falconer (1960) formula.

Correlation(r) is expressed as follows:

$$\text{correlation (r)} = \quad r(Xi\,.Xj) = \frac{Cov(Xi\,.Xj)}{\sqrt{v(Xi).v(Xj)}}$$

Where,

$r(X_i . X_j)$ = Correlation between X_i and X_j

$Cov(X_i . X_j)$ = Covariance between X_i and X_j

$v(X_i)$ = Variance of X_i

$v(X_j)$ = Variance of X_j

Genotypic coefficient of correlation (r_g) = $r(Xi . Xj)g = \frac{Cov(Xi . Xj)g}{\sqrt{v(Xi).v(Xj)g}}$

Where,

$r(X_i . X_j)g$ = Genotypic correlation between X_i and X_j

$Cov(X_i . X_j)_g$ = Genotypic covariance between X_i and X_j

$v(X_i)g$ = Genotypic variance of X_i

$v(X_j)g$ = Genotypic variance of X_j

Phenotypic coefficient of correlation(r_p) = $r(Xi . Xj)p = \frac{Cov(Xi . Xj)p}{\sqrt{v(Xi).v(Xj)p}}$

Where,

$r(X_i . X_j)p$ = Phenotypic correlation between X_i and X_j

$Cov(X_i . X_j)_p$ = Phenotypic covariance between X_i and X_j

$v(X_i)p$ = Phenotypic variance of X_i

$v(X_j)p$ = Phenotypic variance of X_j

Error coefficient of correlation (r_e) = $r(Xi . Xj)e = \frac{Cov(Xi . Xj)e}{\sqrt{v(Xi).v(Xj)e}}$

Where,

$r(X_i . X_j)e$ = Error correlation between X_i and X_j

$Cov(X_i . X_j)_e$ = Error covariance between X_i and X_j

$v(X_i)e$ = Error variance of X_i

$v(X_j)g$ = Error variance of X_j

3.6.4 PATH ANALYSIS

The concept was originally developed by Wright (1921), but this was first used for plant selection by Dewey and Lu (1959). Path analysis is a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effect and measures direct and indirect contribution of each independent variable on the dependent variable. The following set of simultaneous equations were formed and solved for estimating the direct and indirect effects.

$$r_{in} = \sum_{j}^{n} =1\ r_{ij}p_j$$

Where,

$r_{ij} = 1 : i = 1, 2,........n$

The simultaneous equations were presented in matrix form as:

$$\begin{vmatrix} r1y \\ r2y \\ r3y \\ ...... \\ ...... \\ r_{ny} \end{vmatrix} = \begin{vmatrix} 1 & r12 & r13................r1n \\ r21 & 1 & r23................r2n. \\ r31 & r32 & 1..................r3n \\ & .... & \\ & .... & \\ r_{n1} & r_{n2} & r_{n3} \qquad\qquad 1 \end{vmatrix} \begin{vmatrix} P1y \\ P2y \\ P3y \\ .... \\ .... \\ P_{ny} \end{vmatrix}$$

If A = BC

Ths solution for the vector 'C' was obtained by multiplying both sides by inverse of 'B' matrix *i.e* B^{-1}

Thus $B^{-1}A = C$

After calculating the path coefficient value, the path value for residual effect (E) was calculated as follows:

$P_{EX} = \sqrt{1}- (P_{1y}r_{1y}) - (P_{2y}r_{2y}) - (P_{3y}r_{3y})...................- (P_{ny}r_{ny})$

3.6.5 CLUSTER ANALYSIS

This is a numerical approach used for measuring genetic divergence in the germplasm collection.

Main steps involves

1. Computation of D^2 values and testing their significance.
2. Finding the contribution of individual character to the total divergence.
3. Grouping of different genotypes into various clusters.
4. Estimation of average intra and inter cluster distance.
5. Construction of cluster diagram.

For computing D^2 values , 'X' values were transformed 'Y', a linear function in x, so that y = Ax have a unit variance-covariance matrix and y_1, y_2,......y_n are mutually correlated. The following computational steps were followed as described by Rao (1952).

i. A common dispersion matrix (variance-covariance) of correlated variables (X_1, X_2........ Xn) were computed using computes programme.

ii. A set of uncorrelated linear function, y^s were obtained by pivotal condensation of the common dispersion matrix of correlated variables, X^S as suggested by Rao (1952).

iii. Using the relations between Y^S and X^S, the mean values of different varieties for different characters were transformed into the mean values of a set of uncorrelated linear combinations (Y^S).

iv. By using transformed uncorrelated variables (Y^S) , the D^2 between i^{th} and j^{th} for 'n' characters were computed as

$$D^2_{ij} = \sum_{t=1} (y_{it}-y_{jt})^2$$

The 'n' components D^2 were calculated separately and added upto give D^2_{ij}

v. The 'n' components D^2 for each combination were ranked in descending order of magnitude, equal values if any, putting in the same rank.

vi. The ranks were added up each component D^2 over all combinations to get total rank.

vii. The D^2 values obtained for a pair of population was taken as the calculated value of chi-square and tested against the tabulated value of chi-square.

3.6.5.1 Computational step for deriving group constellations

i. Starting from the matrix Y values, the between product sum (v-matrix) for the characters was computed (matrix A).

ii. The fourth power of matrix A was computed to quicker the iteration process.

iii. Conical vector I was computed and the first conical root was extracted simultaneously.

iv. The residual matrix after eliminating vector I was found out and the process was repeated to get the next vector and so on until the first four vectors and roots were obtained.

v. The mean values of the first two vectors Z_1 and Z_2 were computed for each genotype.

vi. Sum of all conical roots and percentage condition of the first four roots to the total variation were computed.

3.6.5.2 Average intra-cluster Divergence (D^2)

Average inter cluster D^2 was computed as the sum of D^2 values between the populations of cluster divided by the product of the number of genotypes in the two clusters.

3.6.5.3. Intra and Inter cluster distance

Intra and Inter cluster distances were calculated by the square root of the average intra and inter cluster D^2 values. The mutual relationship between the clusters and their distances were represented diagrammatically using D^2 value as the statistical distance.

RESULT

4. RESULTS

The present experiment was carried out to analyze variability in fodder rice bean genotypes (*Vigna umbellata* (Thunb.) at College of Agriculture, Vellayani with an objective to identify high yielding superior fodder rice bean genotypes for yield and quality. The observations have been presented and elucidated in this chapter. Experimental results of present investigation are explained under following captions.

4.1. Analysis of variance

4.2. Mean performance

4.3. Genetic parameters

4.4. Correlation studies

4.5. Path analysis

4.6. Cluster analysis

4.1 ANALYSIS OF VARIANCE

Observable differences in individual for particular traits is referred as analysis of variance and was performed to know extent of variation among thirty rice bean genotypes. Analysis of variance was done for all the characters to test the significant difference among thirty fodder rice bean genotypes and ANOVA is presented in Table2.

Analysis of variance revealed that all thirty genotypes differed significantly, indicating considerable variability among genotypes.

Analysis of variance was carried out for all the senenteen characters *i.e* days to first flowering, days to 50% flowering, plant height, number of branches, number of leaves, leaf fresh weight, stem fresh weight, green fodder yield, leaf dry weight, stem dry weight,

Table2. Analysis of variance (mean square) for fodder yield and its components in fodder rice bean

SL. No.	Source of variation	Genotype	Replication	Error	F calculated	F critical
1	Degrees of freedom(df)	29	2	58		
2	Days to first flowering	18.86	13.01	5.89	3.19	1.663
3	Days to 50% flowering	3.89	8.47	3.38	1.15	1.663
4	Plant height	223.77	134.67	31.78	7.04	1.663
5	Number of branches	0.74	1.18	0.32	3.41	1.663
6	Number of leaves	23.60	4.24	6.91	2.32	1.663
7	Leaf fresh weight	22.03	3.74	4.11	5.35	1.663
8	Stem fresh weight	19.23	6.18	8.54	2.25	1.663
9	Green fodder yield	32.35	21.78	10.24	3.15	1.663
10	Leaf dry weight	0.46	0.19	0.09	5.00	1.663
11	Stem dry weight	0.63	0.13	0.13	4.66	1.663
12	Dry fodder yield	2.64	1.18	0.24	10.82	1.663
13	Leaf area index	1.41	0.06	0.05	26.99	1.663
14	Leaf: stem ratio	0.031	0.0091	0.014	2.17	1.663
15	Production efficiency	0.015	0.017	0.005	2.87	1.663
16	Crude protein	10.58	16.32	0.576	18.37	1.663
17	Crude fibre	3.673	2.464	0.089	41.25	1.663
18	Dry matter production	2.34	0.01	0.03	76.76	1.663

dry fodder yield, leaf area index, leaf stem ratio, production efficiency, crude protein, crude fibre and dry matter production.

Result revealed that mean sum of square due to genotypes was highly significant for all the characters under studied except for days to 50% flowering. Considerable amount of variability was reported for all the yield and quality attributing traits. Maximum variability was observed for green fodder yield and minimum for leaf stem ratio.

The magnitude of variability in decreasing order of magnitude for other traits were green fodder yield, leaf fresh weight, stem fresh weight, dry fodder yield, dry matter production, plant height, stem dry weight, leaf dry weight, number of leaves, days to first flowering, crude protein, days to 50% flowering, crude fibre, production efficiency, leaf area index, number of leaves and leaf stem ratio.

4.2 MEAN PERFORMANCE

The crop was harvested at 50% flowering stage. Observations were taken for all the characters at the time of harvest.

4.2.1 Mean performance of biometric characters of rice bean

The mean performance of thirty genotypes of fodder rice bean for all the characters studied are presented in the Table 3. (Fig.1)

4.2.1.1 Days to first flowering

Early flowering was observed in the genotype IC8565-3 (34 DAS) followed by IC341991 (34.33 DAS) and IC341998 (34. 67 DAS), whereas late flowering was observed in the genotypes IC521134 (42.33 DAS) and IC521143 (42.33 DAS) followed by IC521115 42 DAS), IC521116 (41.33 DAS) and IC521152 (41 DAS).

4.2.1.2 Days to 50% flowering

Genotypes IC8565-3, IC19338, IC341991 and IC469195 had taken minimum number of days (47 DAS) to attain 50% flowering. Maximum number of days to reach

50% flowering was observed in the genotypes IC521115, IC521128 and IC521134 (50.33 DAS).

4.2.1.3 Plant height

Highest plant height was observed in the genotype IC521119 (145.07 cm) followed by IC341991 (132 cm) and IC521134 (130.8 cm). Least plant height was observed in the genotypes EC98452 (101.23 cm), IC2567 (103.87 cm) and IC469192 (110.13 cm).

4.2.1.4 Number of branches

Highest number of branches was observed in the genotype IC8565-3 (5.26), IC341991 (5.25) and IC521145 (5.13). Minimum number of branches was recorded for the genotypes EC98452 (3.33), IC341997 (3.35) and IC341998 (3.4).

4.2.1.5 Number of leaves

Genotype IC521134 (32.4) showed maximum number of leaves followed by IC521350 (30.6) and IC341991 (29.4). Minimum number of leaves was observed in the genotypes IC341998 (20.47), EC98452 (21.33) and EC16136 (21.47).

4.2.1.6 Leaf area index `

Leaf area index was varied from 2.15 to 4.64, maximum LAI was recorded by the genotype IC18553 followed by IC521114 (4.51) and IC521128 (4.48). Minimum LAI was recorded by the genotype IC18456, IC18465 (2.35) and EC98452 (2.46).

4.2.1.7 Leaf Stem ratio

Highest leaf: stem ratio was observed in the genotypes IC521114 (0.82), IC521145 (0.79), IC521128 (0.79) and IC469192 (0.78). Genotypes EC98452 (0.42), IC521150 (0.45) and IC521122 (0.5) recorded lowest leaf stem ratio.

Table 3a. Mean performance of biometric characters of fodder rice bean

Sl. No.	Genotypes	Days to first flowering (days)	Days to 50% flowering (days)	Plant height (cm)	Number of branches
1	EC16136	38.33	48.33	113.93	4.4
2	EC18260	38.67	48.33	114.00	4.46
3	EC98452	40.33	50.00	101.23	3.33
4	IC2567	40.67	49.67	103.87	4.73
5	IC8565-3	34.00	47.00	114.00	5.26
6	IC15640	38.33	48.00	123.93	4.93
7	IC18456	37.67	47.67	113.13	3.93
8	IC18465	40.67	48.67	120.87	4.33
9	IC18553	35.33	47.67	127.33	4.46
10	IC19338	38.00	47.00	122.40	4.26
11	IC341986	37.33	48.00	128.47	4.26
12	IC341991	34.33	47.00	132.00	5.25
13	IC341997	35.00	47.33	116.23	3.35
14	IC341998	34.67	49.67	119.28	3.4
15	IC469192	38.67	48.67	110.13	3.93
16	IC469195	34.33	47.00	114.35	4.4
17	IC521114	40.67	48.67	122.50	4.33
18	IC521115	42.00	50.33	124.87	4.53
19	IC521116	41.33	49.67	125.07	4
20	IC521119	39.67	49.67	145.07	4.26
21	IC521122	40.00	49.33	116.67	4.21
22	IC521123	40.00	50.00	117.53	3.93
23	IC521128	38.00	50.33	124.69	4.26
24	IC521134	42.33	50.33	130.80	4.9
25	IC521143	42.33	49.67	125.87	4.73
26	IC521145	40.67	50.00	125.07	5.13
27	IC521149	37.00	48.00	123.76	4.26
28	IC521150	37.67	47.67	118.67	4.53
29	IC521152	41.00	48.33	126.00	4.73
30	IC521350	39.67	47.67	115.79	4.73
Mean		31.11	48.65	120.58	4.37
SE		1.40	1.06	3.25	0.32
CD		3.97	N/A	9.24	0.92

Table 3b. Mean performance of biometric characters of fodder rice bean

Sl. No.	Genotypes	Number of leaves	Leaf area index	Leaf stem ratio
1	EC16136	21.47	2.68	0.64
2	EC18260	25.93	3.06	0.52
3	EC98452	21.33	2.46	0.42
4	IC2567	27.27	3.23	0.71
5	IC8565-3	27.47	2.55	0.66
6	IC15640	22.27	3.26	0.73
7	IC18456	24.27	2.15	0.60
8	IC18465	24.27	2.35	0.72
9	IC18553	24.60	4.64	0.62
10	IC19338	24.87	3.39	0.61
11	IC341986	28.73	4.19	0.77
12	IC341991	29.40	4.22	0.68
13	IC341997	25.53	3.32	0.63
14	IC341998	20.47	3.09	0.70
15	IC469192	22.73	3.84	0.78
16	IC469195	27.07	4.23	0.71
17	IC521114	23.47	4.51	0.82
18	IC521115	25.13	4.05	0.55
19	IC521116	25.20	3.29	0.61
20	IC521119	27.13	3.59	0.69
21	IC521122	22.87	2.58	0.50
22	IC521123	26.33	3.12	0.74
23	IC521128	28.40	4.48	0.79
24	IC521134	32.40	4.12	0.61
25	IC521143	26.87	3.28	0.54
26	IC521145	26.33	4.20	0.79
27	IC521149	29.00	3.47	0.67
28	IC521150	27.20	4.04	0.45
29	IC521152	25.67	3.33	0.68
30	IC521350	30.60	3.50	0.71
Mean		25.80	3.47	0.65
SE		1.51	0.13	0.06
CD		4,30	0.37	0.19

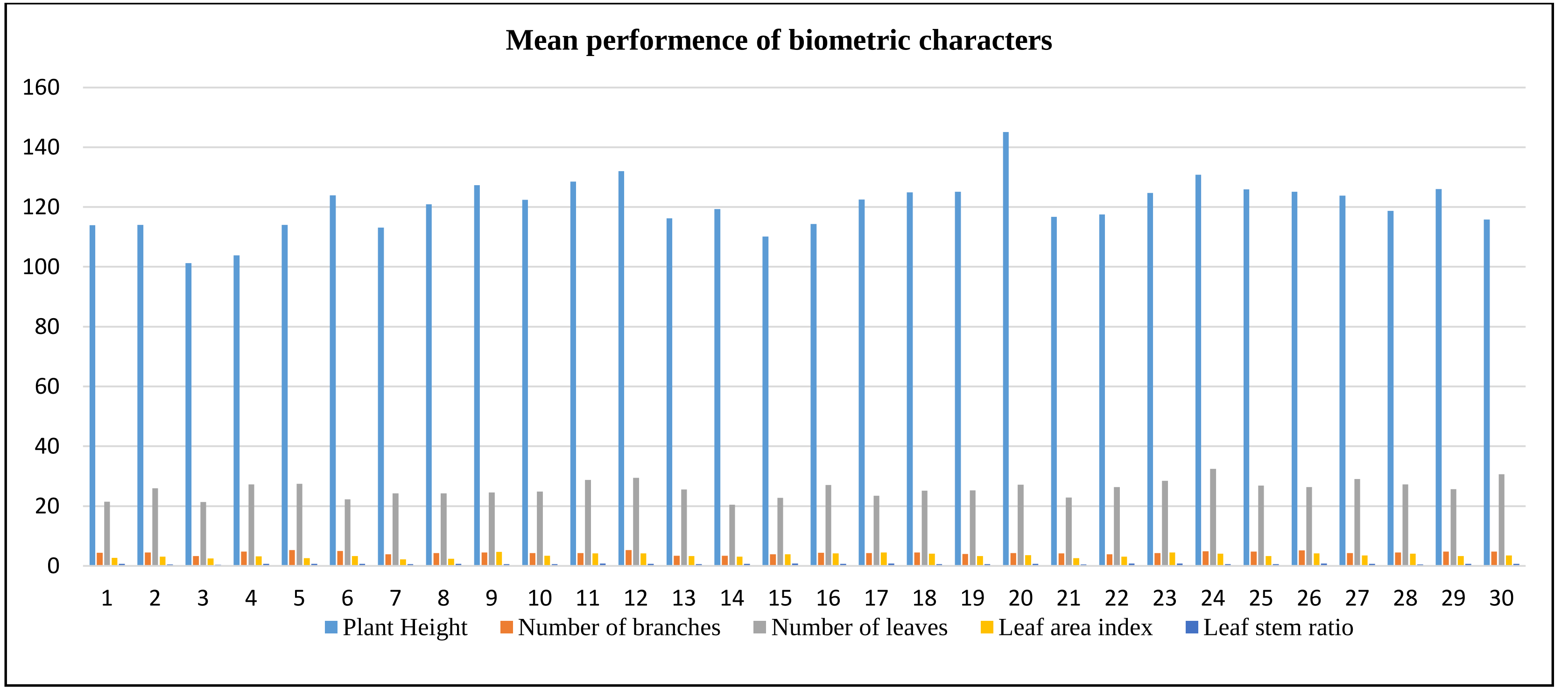

Fig1. Mean performance of biometric characters of fodder rice bean.

4.2.2 Quality parameters

Mean performance of crude protein and crude fibre is presented in Table 4.

4.2.2.1 Crude protein

Crude protein percentage was ranged from 13.30% to 21%. Highest crude protein content was recorded in the genotype IC521119 (21%), followed by IC521152 (20.27%) and IC521115 (19.74%). Lowest crude protein percentage was observed in the genotypes IC18553 (13.30%), IC15640 (14.19%) and IC52112 (14.39%).

4.2.2.2 Crude fibre

Crude fibre content value found to be maximum for the genotypes IC469192 (6.7%), IC521145 (6.6%) and EC18260 (6.5%). Minimum value was reported by the genotype EC98452 (2.8%) preceded by the genotypes IC8565-3 (2.9%) and IC2567 (3.1%).

4.2.3 Yield attributes

Mean performance of yield attributes of fodder rice bean is presented in Table5. (Fig. 2).

4.2.3.1 Leaf fresh weight

Leaf fresh weight was more for the genotypes IC521134 (17.76 t ha^{-1}), IC341991 (17.42 t ha^{-1}) and IC521145 (16.61 t ha^{-1}). Least leaf fresh weight was recorded for the genotypes EC98452 (8.45 t ha^{-1}), IC18465 (8.67 t ha^{-1}) and IC341998 (8.79 t ha^{-1}).

4.2.3.2 Stem fresh weight

Highest stem fresh weight was observed in the genotype IC341991 (21.88 t ha^{-1}) followed by IC521350 (21.78 t ha^{-1}) and IC521119 (20.31 t ha^{-1}). Genotypes EC98452 (12.64 t ha^{-1}), EC16136 (13.23 t ha^{-1}) and IC521123 (13.72 t ha^{-1}) had recorded minimum stem fresh weight.

Table 4. Mean performance of quality attributes of fodder rice bean

Sl. No.	Genotypes	Crude protein (%)	Crude fibre (%)
1	EC16136	19.09	4.57
2	EC18260	18.33	6.57
3	EC98452	18.10	2.80
4	IC2567	17.44	3.10
5	IC8565-3	16.38	2.97
6	IC15640	14.19	4.30
7	IC18456	15.00	5.27
8	IC18465	14.70	3.90
9	IC18553	13.30	6.30
10	IC19338	16.15	6.10
11	IC341986	17.19	4.53
12	IC341991	17.12	6.17
13	IC341997	17.71	4.30
14	IC341998	15.99	4.47
15	IC469192	17.80	6.70
16	IC469195	16.08	5.43
17	IC521114	16.46	6.27
18	IC521115	19.74	3.97
19	IC521116	15.16	6.03
20	IC521119	21.00	4.80
21	IC521122	14.39	6.30
22	IC521123	18.13	4.50
23	IC521128	18.17	5.17
24	IC521134	18.89	5.87
25	IC521143	16.78	5.50
26	IC521145	19.04	6.67
27	IC521149	15.12	5.17
28	IC521150	15.99	4.37
29	IC521152	20.27	5.30
30	IC521350	17.42	5.67
Mean		17.03	5.10
SE		0.43	0.17
CD		1.24	0.48

4.2.3.3 Green fodder yield

Maximum green fodder yield was recorded by the genotype IC341991 (35.49 t ha^{-1}), IC341986 (34.42 t ha^{-1}), IC521350 (32.78 t ha^{-1}) and IC521134 (32.33 t ha^{-1}). Lowest green fodder yield was observed in the genotypes EC98452 (22.32 t ha^{-1}), IC341998 (23.25 t ha^{-1}) and EC16136 (24.12 t ha^{-1}).

4.2.3.4 Leaf dry weight

Leaf dry weight was found to be maximum for the genotypes IC341986 (2.77t ha^{-1}), IC341991 (2.6 t ha^{-1}) and IC521145 (2.5 t ha^{-1}). Minimum leaf dry weight was recorded for the genotypes EC98452 (0.93 t ha^{-1}), IC521122 (1.32 t ha^{-1}) and IC18456 (1.37 t ha^{-1}).

4.2.3.5 Stem dry weight

Highest stem dry weight was reported in the genotype IC341991 (3.82 t ha^{-1}) followed by IC341986 (3.6 t ha^{-1}) and IC521134 (3.58 t ha^{-1}). Lowest stem dry weight was observed in the genotypes IC521123 (1.91 t ha^{-1}), EC98452 (2.20 t ha^{-1}) and EC16136 (2.3 t ha^{-1}).

4.2.3.6 Dry fodder yield

Dry fodder yield was reported to be highest for the genotypes IC341991 (6.27 t ha^{-1}), IC341986 (5.93 t ha^{-1}) and IC521145 (5.88 t ha^{-1}).Genotype EC98452 recorded lowest dry fodder yield of 2. 94 t ha^{-1} followed by IC18456 (2.99 t ha^{-1}) and IC521122 (3.18 t ha^{-1}).

4.2.3.7 Production efficiency

Production efficiency values ranged from 0.450 to 0.755. Highest value was recorded by the genotype IC341991 (0.755), this was statistically on par with the genotypes IC341986 (0.718) and IC521350 (0.687). Lowest was recorded by the genotype EC98452 (0.450), preceded by IC341998 (0.469) and EC16136 (0.499).

4.2.3.8 Dry matter production

Maximum dry matter production was observed in the genotype IC341991 (6.972t ha^{-1}) followed by IC521114 (6.579t ha^{-1}) and IC521134 (6.176t ha^{-1}). Minimum was recorded by the genotypes IC521123 (3.274 t ha^{-1}), EC98452 (3.399 t ha^{-1}) and IC521122 (3.678 t ha^{-1}).

Table 5a. Mean performance of yield attributes of fodder rice bean

Sl. No.	Genotypes	Leaf fresh weight (t ha^{-1})	Stem fresh weight (t ha^{-1})	Green fodder yield (t ha^{-1})	Leaf dry weight (t ha^{-1})
1	EC16136	10.80	13.23	24.13	1.47
2	EC18260	12.35	15.46	27.80	1.81
3	EC98452	8.45	12.64	22.32	0.93
4	IC2567	9.01	14.31	28.86	1.91
5	IC8565-3	14.99	16.04	28.61	2.11
6	IC15640	12.25	17.44	28.00	2.16
7	IC18456	10.68	16.76	26.31	1.37
8	IC18465	8.67	15.11	25.40	1.91
9	IC18553	9.58	19.20	30.50	1.67
10	IC19338	10.19	18.45	28.71	1.76
11	IC341986	15.68	19.55	34.42	2.77
12	IC341991	17.42	21.88	35.49	2.60
13	IC341997	12.54	20.26	27.26	1.86
14	IC341998	8.79	15.70	23.25	1.91
15	IC469192	12.30	15.33	25.67	2.06
16	IC469195	12.69	13.94	29.05	2.16
17	IC521114	10.48	18.10	31.46	2.40
18	IC521115	11.07	16.39	31.13	1.86
19	IC521116	11.10	15.16	26.55	1.89
20	IC521119	13.84	20.31	31.43	2.01
21	IC521122	10.17	17.29	27.55	1.32
22	IC521123	10.46	13.72	25.11	1.42
23	IC521128	14.82	16.90	31.75	2.06
24	IC521134	17.76	20.16	32.33	2.18
25	IC521143	10.83	17.42	30.57	1.52
26	IC521145	16.61	18.20	31.48	2.50
27	IC521149	14.99	17.20	31.97	1.76
28	IC521150	14.40	19.62	31.11	1.62
29	IC521152	9.97	20.26	29.39	1.91
30	IC521350	15.41	21.78	32.78	1.86
Mean		12.27	17.25	29.04	1.89
SE		1.17	1.68	1.84	0.18
CD		3.32	4.78	5.24	0.52

Table 5b. Mean performance of yield attributes of fodder rice bean

Sl. No.	Genotypes	Stem dry weight (t ha^{-1})	Dry fodder yield (t ha^{-1})	Production efficiency (t ha^{-1})	Dry matter production (t ha^{-1})
1	EC16136	2.30	4.07	0.499	4.620
2	EC18260	3.43	3.43	0.577	5.236
3	EC98452	2.20	2.94	0.450	3.399
4	IC2567	2.69	3.58	0.583	4.633
5	IC8565-3	3.28	4.21	0.609	5.520
6	IC15640	2.99	5.44	0.583	6.056
7	IC18456	2.30	2.99	0.552	3.942
8	IC18465	2.69	4.26	0.523	5.189
9	IC18553	2.69	3.82	0.640	5.426
10	IC19338	2.89	4.16	0.611	5.203
11	IC341986	3.60	5.93	0.718	6.124
12	IC341991	3.82	6.27	0.755	6.972
13	IC341997	2.99	4.29	0.577	5.193
14	IC341998	2.30	3.48	0.469	4.466
15	IC469192	2.60	4.31	0.530	5.283
16	IC469195	3.04	5.59	0.618	6.028
17	IC521114	2.94	4.61	0.667	6.579
18	IC521115	3.43	4.31	0.622	5.331
19	IC521116	3.14	3.58	0.537	4.927
20	IC521119	2.94	5.39	0.632	5.723
21	IC521122	2.65	3.18	0.559	3.678
22	IC521123	1.91	3.09	0.501	3.274
23	IC521128	2.69	4.90	0.632	5.929
24	IC521134	3.58	5.34	0.641	6.176
25	IC521143	2.79	4.12	0.619	4.698
26	IC521145	3.18	5.88	0.633	4.768
27	IC521149	2.69	4.85	0.667	4.935
28	IC521150	3.58	4.16	0.655	5.454
29	IC521152	2.84	5.07	0.608	5.203
30	IC521350	2.69	5.44	0.687	6.070
Mean		2.29	4.42	0.59	5.20
SE		0.21	0.28	0.04	0.10
CD		0.60	0.81	0.11	0.28

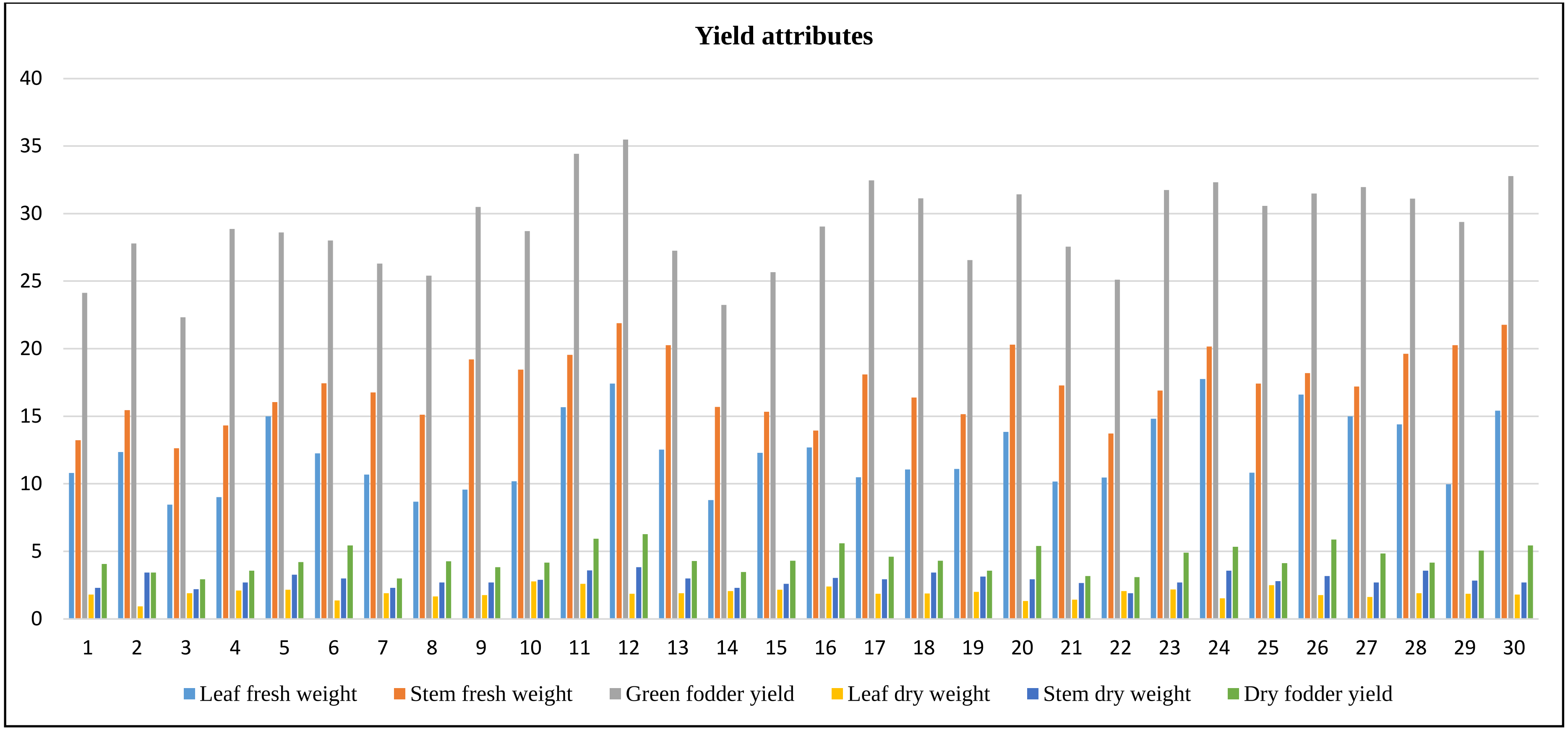

Fig 2. Mean performance of yield attributes of fodder rice bean

4.3 ESTIMATION OF DIFFERENT PARAMETERS OF GENETIC VARIABILITY

The genetic variability parameters *viz*., genotypic coefficient of variation (GCV) and phenotypic coefficient of variation(PCV), heritability in broad sense(%), genetic advance as percentage of mean for all the seventeen characters under study were analyzed. The results are given in the Table 6.

4.3.1 Genotypic coefficient of variation

Genotypic coefficient of variation varies from 0.84% to 21.42% for various characters under study.

Maximum value of genotypic coefficient of variation was observed for the characters crude fibre (21.42%) and dry fodder yield (20.22%) and moderate values were observed for the characters leaf fresh weight (19.91%), leaf area index(19.51), leaf dry weight (18.53%), dry matter production (16.89%), stem dry weight (14.02%), leaf stem ratio (11.43%), stem fresh weight (10.94%) and crude protein (10.72%)

Minimum value of genotypic coefficient of variation were observed for the characters days to 50% flowering (0.84), days to first flowering (5.38%), plant height (6.63%), number of branches (8.59%), number of leaves (9.13%), green fodder yield (9.34%) and production efficiency (9.55%). (Fig. 3)

4.3.2 Phenotypic coefficient of variation

Maximum phenotypic coefficient of variation were observed for the traits leaf fresh weight (25.87%), leaf dry weight (24.51%), dry fodder yield (23.11%), crude fibre (22.21%), leaf stem ratio (21.55%), leaf area index (20.6) and stem fresh weight (20.15%). Moderate values were observed for the characters stem dry weight (18.91), dry matter production (17.23%), number of branches (15.53%), production efficiency (15.41%), green fodder yield (14.44%), number of leaves (13.68%) and crude protein (11.61%).

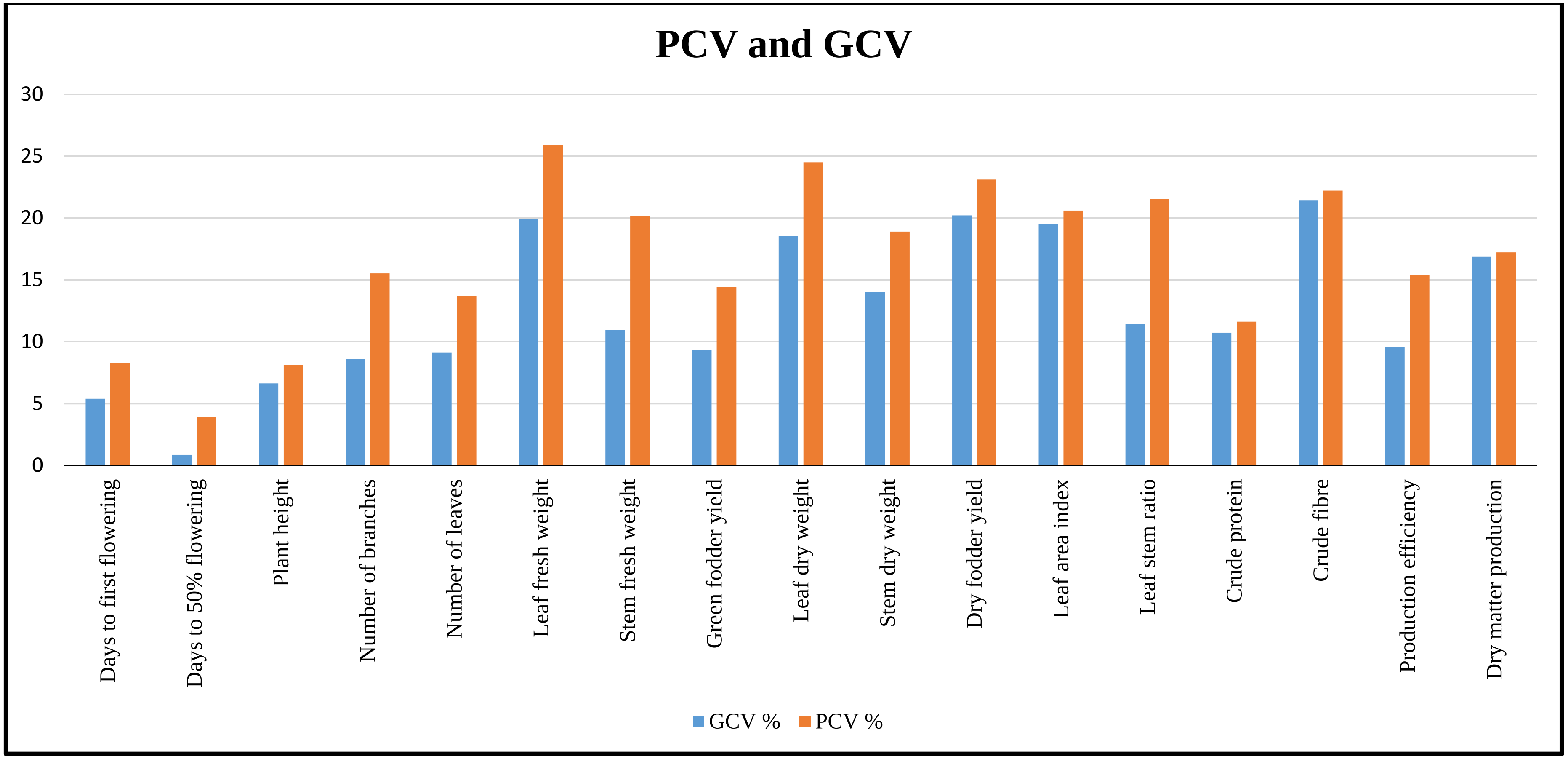

Fig.3. GCV and PCV for the fodder rice bean genotypes

Lowest phenotypic coefficient of variation were observed for the characters days to 50% flowering (3.87%), days to first flowering (8.27) and plant height (8.11%).

4.3.3 Heritability estimates

High estimates of heritability was observed for the traits dry matter production (96.19%), crude fibre (93.06%), leaf area index (89.65%), crude protein (85.27%), dry fodder yield (76.6%), and plant height (66.81%). Moderate heritability estimates were recorded for the traits leaf fresh weight (59.22%), leaf dry weight (57.14%) and stem dry weight (54.98%).

Heritability estimates were found to be least for the traits days to 50% flowering (4.78%), leaf stem ratio (28.13%), stem fresh weight (29.45%), number of branches (30.62%), production efficiency (38.4%), green fodder yield (41.84%), days to first flowering (42.3%) and number of leaves (44.59).

4.3.4 Genetic advance as percentage of mean

Highest values for genetic advance were recorded for the characters crude fibre (42.58%), leaf area index (38.06%), dry fodder yield (36.47%), dry matter production (34.14%), leaf fresh weight (3.56%), leaf dry weight (28.85%) stem dry weight (21.43%) and crude protein (20.39%). Moderate values were recorded for the traits number of leaves (12.57%), leaf stem ratio (12.49%), green fodder yield (12.45%), stem fresh weight (12.23%), production efficiency (12.19%) and plant height (11.17%). (Fig.4).

Lowest values of genetic advance were recorded for the traits days to 50% flowering (0.38%), days to first flowering (7.21%) and number of branches (9.79%).

Table 6. Estimates of genetic parameters for various characters of fodder rice bean

Sl No	Characters	GCV (%)	PCV (%)	Heritability (%)	Genetic advance as percentage of mean
1	Days to first flowering	5.38	8.27	42.3	7.21
2	Days to 50% flowering	0.84	3.87	4.78	0.38
3	Plant height	6.63	8.11	66.81	11.17
4	Number of branches	8.59	15.53	30.62	9.79
5	Number of leaves	9.13	13.68	44.59	12.57
6	Leaf fresh weight	19.91	25.87	59.22	31.56
7	Stem fresh weight	10.94	20.15	29.45	12.23
8	Green fodder yield	9.34	14.44	41.84	12.45
9	Leaf dry weight	18.53	24.51	57.14	28.85
10	Stem dry weight	14.02	18.91	54.98	21.43
11	Dry fodder yield	20.22	23.11	76.6	36.47
12	Leaf area index	19.51	20.6	89.65	38.06
13	Leaf stem ratio	11.43	21.55	28.13	12.49
14	Crude protein	10.72	11.61	85.27	20.39
15	Crude fibre	21.42	22.21	93.06	42.58
16	Production efficiency	9.55	15.41	38.4	12.19
17	Dry matter production	16.89	17.23	96.19	34.14

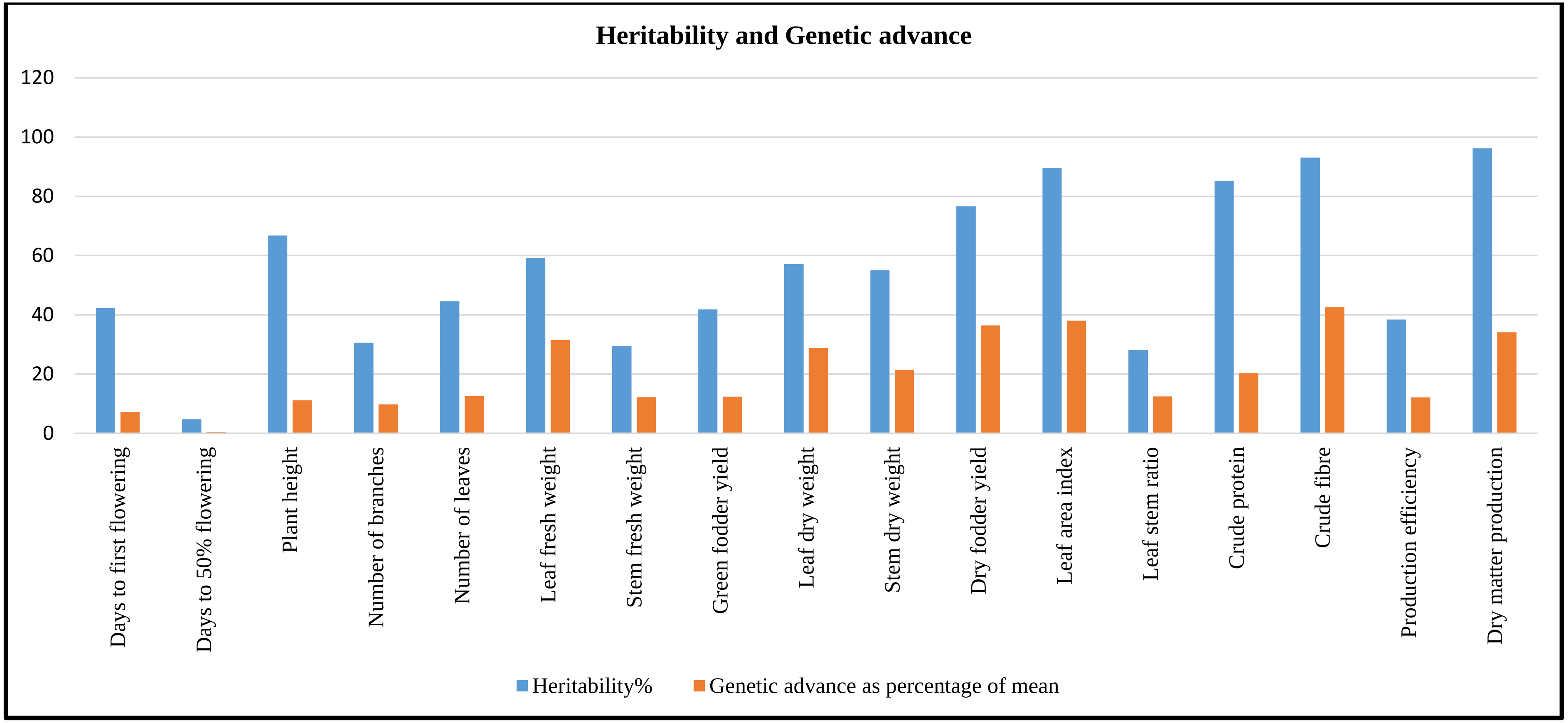

Fig 4. Heritability and genetic advance for fodder rice bean genotypes

4.4 CORRELATION COEFFICIENT ANALYSIS

Phenotypic and genotypic correlations for various characters were estimated. The results are presented in the Table 7.

4.4.1Genotypic correlation coefficients

4.4.1.1 Days to first flowering

Days to first flowering had positive correlation with days to 50% flowering (0.99) and crude protein (0.437) whereas characters leaf dry weight (-0.231), leaf fresh weight (-0.253) and dry matter production (-0.301) showed negative correlation with days to first flowering.

4.4.1.2 Days to 50% flowering

Days to 50% flowering showed positive correlation with days to first flowering (0.99) and crude protein (0.98) whereas characters leaf fresh weight (-0.221), leaf dry weight (-0.249), crude fibre (-0.308), production efficiency (-0.343), dry fodder yield (-0.396), stem dry weight (-0.532), number of branches (-0.621), stem fresh weight (-0.702) and dry matter production (-0.991) had negative correlation with days to 50% flowering.

4.4.1.3 Plant height

Plant height showed positive correlation with stem fresh weight (0.886), green fodder yield (0,822), production efficiency (0.773), dry fodder yield (0.644), dry matter production (0.548), leaf area index (0.539), stem dry weight (0.534), leaf dry weight (0.524), number of leaves (0.502), leaf fresh weight (0.478), number of branches (0.389), crude fibre (0.37) and leaf stem ratio (0.224).

Table 7. Genotypic correlation coefficient matrix among characters of fodder rice bean

	X1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X 10	X 11	X 12	X 13	X 14	X 15	X 16
X1																
X2	0.99^{**}															
X3	0.139^{NS}	0.182^{NS}														
X4	0.184^{NS}	-0.621^{**}	0.389^{**}													
X5	0.084^{NS}	0.192^{NS}	0.502^{**}	0.757^{**}												
X6	-0.253^{*}	-0.221^{*}	0.478^{**}	0.624^{**}	0.935^{**}											
X7	-0.138^{NS}	-0.702^{**}	0.886^{**}	0.528^{**}	0.686^{**}	0.805^{**}										
X8	0.001^{NS}	-0.200^{NS}	0.822^{**}	0.860^{**}	0.996^{**}	0.899^{**}	0.993^{**}									
X9	-0.231^{*}	-0.249^{*}	0.524^{**}	0.711^{**}	0.488^{**}	0.708^{**}	0.521^{**}	0.780^{**}								
X10	-0.104^{NS}	-0.532^{**}	0.534^{**}	0.723^{**}	0.602^{**}	0.793^{**}	0.616^{**}	0.908^{**}	0.750^{**}							
X11	-0.081^{NS}	-0.396^{**}	0.644^{**}	0.770^{**}	0.636^{**}	0.843^{**}	0.728^{**}	0.900^{**}	0.900^{**}	0.669^{**}						
X12	-0.144^{NS}	-0.064^{NS}	0.539^{**}	0.423^{**}	0.542^{**}	0.536^{**}	0.580^{**}	0.903^{**}	0.708^{**}	0.580^{**}	0.642^{**}					
X13	-0.171^{NS}	0.155^{NS}	0.224^{*}	0.468^{**}	0.249^{*}	0.296^{**}	0.163^{NS}	0.275^{**}	0.708^{**}	0.093^{NS}	0.702^{**}	0.511^{**}				
X14	-0.138^{NS}	-0.343^{**}	0.773^{**}	0.878^{**}	0.97^{**}	0.893^{**}	0.985^{**}	0.991^{**}	0.778^{**}	0.932^{**}	0.912^{**}	0.886^{**}	0.242^{*}			
X15	0.437^{**}	0.98^{**}	0.192^{NS}	0.100^{NS}	0.265^{*}	0.263^{*}	0.109^{NS}	0.121^{NS}	0.118^{NS}	0.124^{NS}	0.259^{*}	0.165^{NS}	0.077^{NS}	0.014^{NS}		
X16	0.077^{NS}	-0.308^{**}	0.370^{**}	0.223^{*}	0.168^{NS}	0.275^{**}	0.508^{**}	0.395^{**}	0.285^{**}	0.227^{*}	0.254^{*}	0.442^{**}	0.195^{NS}	0.405^{**}	-0.086^{NS}	

* -Significane at 5%

** -Significant at 1%

X1-Days to first flowering

X2-Days to 50% flowering

X3-Plant height

X4-Number of branches

X5-Number of leaves

X6-Leaf fresh weight

X7-Stem fresh weight

X8-Green fodder yield

X9-Leaf dry weight

X10-Stem dry weight

X11-Dry fodder yield

X12-Leaf area index

X13-Leaf stem ratio

X14-Production efficiency

X15-Crude protein

X16- Crude fibre

X17-Dry matter production

4.4.1.4 Number of branches

Characters such as production efficiency (0.878), green fodder yield (0.86), dry fodder yield (0.77), number of leaves (0.757), stem dry weight (0.723), leaf dry weight (0.7110), dry matter production (0.68), leaf fresh weight (0.624), stem fresh weight (0.528), leaf stem ratio (0.468), leaf area index (0.423), plant height (0.384) and crude fibre (0.223) showed significant positive correlation with number of branches per plant. Number of branches per plant showed negative correlation with days to 50% flowering (0.621).

4.4.1.5 Number of leaves per plant

Number of leaves per plant showed significant positive correlation with characters green fodder yield (0.996), production efficiency (0.97), leaf fresh weight (0.935), number of branches (0.757), stem fresh weight (0.686), dry fodder yield (0.636), stem dry weight (0.602), dry matter production (0.577), leaf area index (0.542), plant height (0.502), leaf dry weight (0.488), crude protein (0.265) and leaf stem ratio (0.249).

4.4.1.6 Leaf fresh weight

Leaf fresh weight showed significant positive correlation with the characters such as number of leaves (0.935), green fodder yield (0.899), production efficiency (0.893), dry fodder yield (0.843), stem fresh weight (0.805), stem dry weight (0.793), leaf dry weight (0.708), dry matter production (0.654), number of leaves (0.624), leaf area index (0.536), plant height (0.478), leaf stem ratio (0.296), crude fibre (0.275) and crude protein (0.263). Leaf fresh weight showed negative correlation with days to first flowering (-0.253) and days to 50% flowering (-0.221).

4.4.1.7 Stem fresh weight

Stem fresh weight was found to positively correlated with production efficiency (0.995), green fodder yield (0.993), plant height (0.886), leaf fresh weight (0.805), dry matter production (0.798), dry fodder yield (0.728), number of leaves (0.686), stem dry weight (0.616), leaf area index (0.58), number of branches (0.528), leaf dry weight (0.521) and crude fibre (0.508). Stem fresh weight showed negative correlation with days to 50% flowering (-0.702).

4.4.1.8 Green fodder yield

Green fodder yield showed positive correlation with number of leaves (0.996), stem fresh weight (0.993), production efficiency (0.991), stem dry weight (0.908), leaf area index (0.903), dry fodder yield (0.9), leaf fresh weight (0.899), dry matter production (0.893), number of branches (0.86), plant height (0.822), leaf dry weight (0.78), crude fibre (0.395) and leaf stem ratio (0.275).

4.4.1.9 Leaf dry weight

Leaf dry weight was positively correlated with the characters dry fodder yield (0.9), dry matter production (0.892), green fodder yield (0.78), production efficiency (0.778), stem dry weight (0.75), number of branches (0.711), leaf fresh weight (0.708), leaf area index (0.708), leaf stem ratio (0.708), plant height (0.524), stem fresh weight (0.521), number of leaves (o.488) and crude fibre (0.285). Leaf dry weight showed negative correlation with days to 50% flowering (-0.249) and days to first flowering (0.231).

4.4.1.10 Stem dry weight

Stem dry weight was found to be positively correlated with production efficiency (0.985), green fodder yield (0.908), dry matter production (0.798), leaf fresh weight (0.793), leaf dry weight (0.75), number of branches (0.723), dry fodder yield (0.669), stem fresh weight (0.616), number of leaves (0.602), leaf area index (0.58), plant height (0.534) and crude fibre (0.224). Stem dry weight showed negative correlation with days to 50% flowering (-0.532).

4.4.1.11 Dry fodder yield

Dry fodder yield was observed to have positive correlation with production efficiency (0.912), leaf dry weight (0.9), green fodder yield (0.9), leaf fresh weight (0.843), dry matter production (0.836), number of branches (0.77), stem fresh weight (0.728), leaf stem ratio (0.702), stem dry weight (0.669), plant height (0.644), leaf area index (0.642), number of leaves (0.636), crude protein (0.259) and crude fibre (0.254). Characters days to 50% flowering (-0.396) and days to first flowering (-0.089) showed negative significant correlation with dry fodder yield.

4.4.1.12 Leaf area index

Leaf area index recorded significant positive correlation with green fodder yield (0.903), production efficiency (0.886), leaf dry weight (0.708), dry matter production (0.679), dry fodder yield (0.642), stem fresh weight (0.58), stem dry weight (0.58), number of leaves (0.542), plant height (0.539), leaf fresh weight (0.536), leaf stem ratio (0.511), crude fibre (0.442) and number of branches (0.423).

4.4.1.13 Leaf stem ratio

Leaf stem ratio showed significant positive correlation with leaf dry weight (0.702), dry fodder yield (0.702), dry matter production (0.556), leaf area index (0.511), number of branches (0.468), leaf fresh weight (0.296), green fodder yield (0.275), number of leaves (0.249), production efficiency (0.242) and plant height (0.224).

4.4.1.14 Production efficiency

Production efficiency had positive correlation with stem fresh weight (0.985), number of leaves (0.97), green fodder yield (0.991), dry matter production (0.95), stem dry weight (0.932), dry fodder yield (0.912), leaf fresh weight (0.893), leaf area index (0.886), number of branches (0.878), leaf dry weight (0.778), plant height (0.773), crude fibre (0.405) and leaf stem ratio (0.242). Days to 50% flowering (-0.343) showed negative significant correlation with production efficiency.

4.4.1.15 Crude protein

Crude protein showed positive correlation with days to 50% flowering (0.98), days to first flowering (0.437), number of leaves (0.265), leaf fresh weight (0.263) and dry fodder yield (0.259). Crude fibre (-0.086) showed negative correlation with crude protein.

4.4.1.16 Crude fibre

Crude fibre had positive correlation with stem fresh weight (0.508), leaf area index (0.422), production efficiency (0.405), green fodder yield (0.395), plant height (0.37), leaf dry weight (0.285), leaf fresh weight (0.275), dry matter production (0.257), dry fodder yield (0.254), stem dry weight (0.227) and number of branches (0.223) whereas days to 50% flowering (-0.308) showed negative significant correlation with crude fibre.

4.4.1.17 Dry matter production

Dry matter production showed positive correlation with production efficiency (0.95), green fodder yield (0.893), leaf dry weight (0.892), dry fodder yield (0.836), stem fresh weight (0.798), stem dry weight (0.798), number of branches (0.68), leaf area index (0.679), leaf fresh weight (0.654), number of leaves (0.577), leaf stem ratio (0.556), plant height (0.548) and crude fibre (0.257). Days to 50% flowering (-0.991) and days to first flowering (-0.301) showed negative correlation with dry matter production.

4.4.2 Phenotypic correlation

Phenotypic correlation coefficient among various characters of fodder rice bean is presented in Table 8.

4.4.2.1 Days to first flowering

Days to 50% flowering (0.587) and crude protein (0.254) showed significant positive correlation with days to first flowering.

4.4.2.2 Days to 50% flowering

Days to first flowering (0.584) and crude protein (0.241) had positive correlation on days to first flowering. Dry fodder yield (-0.224), stem fresh weight (-0.232), dry matter production (-0.238) and production efficiency (-0.392) showed negative correlation with days to 50% flowering.

4.4.2.3 Plant height

Plant height showed significant positive correlation with days to first flowering (0.493), dry matter production (0.437), stem fresh weight (0.435), leaf dry weight (0.422), green fodder yield (0.396), leaf area index (0.391), leaf fresh weight (0.358), production efficiency (0.344), stem dry weight (0.333), Crude fibre (0.287), number of branches (0.277), number of leaves (0.251) and leaf stem ratio (0.221).

4.4.2.4 Number of branches

Number of branches observed to have positive correlation with green fodder yield (0.452), stem dry weight (0.447), production efficiency (0.443), leaf fresh weight (0.44), dry fodder yield (0.391), dry matter production (0.377), number of leaves (0.338), leaf dry weight (0.293), plant height (0.277) and stem fresh weight (0.257) whereas days to 50% flowering (-0.001) had negative correlation with number of branches.

4.4.2.5 Number of leaves

Number of leaves had positive correlation with leaf fresh weight (0.583), production efficiency (0.504), green fodder yield (0.499), stem dry weight (0.467), dry fodder yield (0.464), stem fresh weight (0.423), dry matter production (0.387), leaf dry weight (0.347), number of branches (0.338), leaf area index (0.286) and plant height (0,251).

Table 8. Phenotypic correlation coefficients among various characters of fodder rice bean

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
X1																
X2	0.587**															
X3	0.022^{NS}	0.082^{NS}														
X4	0.021^{NS}	-0.079^{NS}	0.277**													
X5	-0.022^{NS}	-0.166^{NS}	0.251*	0.338**												
X6	-0.128^{NS}	-0.168^{NS}	0.358**	0.440**	0.583**											
X7	-0.061^{NS}	-0.232*	0.435**	0.257*	0.423**	0.367*										
X8	-0.012^{NS}	-0.173^{NS}	0.396**	0.452**	0.499**	0.521**	0.550**									
X9	-0.158^{NS}	-0.175^{NS}	0.422**	0.293**	0.347**	0.480**	0.383**	0.507**								
X10	-0.065^{NS}	-0.180^{NS}	0.333**	0.447**	0.467**	0.473**	0.472**	0.483**	0.546**							
X11	-0.184^{NS}	-0.224*	0.493**	0.391**	0.464**	0.595**	0.512**	0.573**	0.676**	0.482**						
X12	-0.012^{NS}	0.058^{NS}	0.391**	0.158^{NS}	0.286**	0.395**	0.368**	0.511**	0.486**	0.386**	0.547**					
X13	-0.090^{NS}	-0.058^{NS}	0.221*	-0.001^{NS}	0.058^{NS}	0.185^{NS}	0.043^{NS}	0.220*	0.683**	-0.207*	0.370**	0.250*				
X14	-0.149^{NS}	-0.392**	0.344**	0.443**	0.504**	0.525**	0.565**	0.973**	0.515**	0.499**	0.583**	0.463**	0.214*			
X15	0.254*	0.241*	0.141^{NS}	0.058^{NS}	0.187^{NS}	0.222*	0.078^{NS}	0.140^{NS}	0.153^{NS}	0.104^{NS}	0.256*	0.110^{NS}	0.102^{NS}	0.072^{NS}		
X16	0.077^{NS}	-0.023^{NS}	0.287**	0.108^{NS}	0.073^{NS}	0.214*	0.227*	0.255*	0.199^{NS}	0.138^{NS}	0.184^{NS}	0.403**	0.125^{NS}	0.242*	-0.084^{NS}	

* -Significane at 5%

** -Significant at 1%

X1-Days to first flowering   X7-Stem fresh weight   X13-Leaf stem ratio

X2-Days to 50% flowering   X8-Green fodder yield   X14-Production efficiency

X3-Plant height   X9-Leaf dry weight   X15-Crude protein

X4-Number of branches   X10-Stem dry weight   X16- Crude fibre

X5-Number of leaves   X11-Dry fodder yield   X17-Dry matter production

X6-Leaf fresh weight   X12-Leaf area index

4.4.2.6 Leaf fresh weight

Characters such as dry fodder yield (0.595), number of leaves (0.583), production efficiency (0.525), green fodder yield (0.521), dry matter production (0.497), leaf dry weight (0.48), stem dry weight (0.473), number of branches (0.44), leaf area index (0.395), stem fresh weight (0.367), plant height (0.358), crude protein (0.222) and crude fibre (0.214) showed positive correlation with leaf fresh weight.

4.4.2.7 Stem fresh weight

Characters such as production efficiency (0.565), green fodder yield (0.55), dry fodder yield (0.512), stem dry weight (0.472), plant height (0.435), number of leaves (0.423), dry matter production (0.42), leaf dry weight (0.383), leaf area index (0.368), leaf fresh weight (0.367), number of branches (0.257) and crude fibre (0.227) showed significant positive correlation with stem fresh weight. Days to 50% flowering (-0.232) recorded negative correlation with stem fresh weight.

4.4.2.8 Green fodder yield

Green fodder yield showed significant positive correlation with production efficiency (0.973), dry fodder yield (0.573), dry matter production (0.553), stem fresh weight (0.55), leaf fresh weight (0.521), leaf area index (0.511), leaf dry weight (0.507), number of leaves (0.499), stem dry weight (0.483), number of branches (0.452), plant height (0.396), crude fibre (0.225) and leaf stem ratio (0.22).

4.4.2.9 Leaf dry weight

Leaf dry weight had positive correlation with leaf stem ratio (0.683), dry fodder yield (0.676), dry matter production (0.652), stem dry weight (0.546), production efficiency (0.515), green fodder yield (0.507), leaf area index (0.486), leaf fresh weight (0.48), plant height (0.422), stem fresh weight (0.383), number of leaves (0.347) and number of branches (0.293).

4.4.2.10 Stem dry weight

Characters such as dry matter production (0.589), leaf dry weight (0.546), production efficiency (0.499), green fodder yield (0.483), dry fodder yield (0.482), leaf fresh weight (0.473), stem fresh weight (0.472), number of leaves (0.467), number of branches (0.447), leaf area index (0.386) and plant height (0.333) showed positive correlation with stem dry weight. Leaf stem ratio (-0.207) had negative correlation with stem dry weight.

4.4.2.11 Dry fodder yield

Dry fodder yield recorded significant positive correlation with dry matter production (0.712), leaf dry weight (0.676), leaf fresh weight (0.595), production efficiency (0.583), green fodder yield (0.573), leaf area index (0.547), stem fresh weight (0.512), plant height (0.493), stem dry weight (0.482), number of leaves (0.464), number of branches (0.391), leaf stem ratio (0.37) and crude protein (0.256). Days to 50% flowering (-0.224) showed negative correlation with dry fodder yield.

4.4.2.12 Leaf area index

Leaf area index showed positive correlation with dry matter production (0.638), dry fodder yield (0.547), green fodder yield (0.511), leaf dry weight (0.486), production efficiency (0.463), crude fibre (0.403), leaf fresh weight (0.395), plant height (0.391), stem dry weight (0.386), stem fresh weight (0.368), number of leaves (0.286) and leaf stem ratio (0.25).

4.4.2.13 Leaf stem ratio

Leaf stem ratio was observed to have significant positive correlation with leaf dry weight (0.683), dry fodder yield (0.37), dry matter production (0.281), leaf area index (0.25), plant height (0.221), green fodder yield (0.22) and production efficiency (0.214).

4.4.2.14 Production efficiency

Green fodder yield (0.973), dry fodder yield (0.583), dry matter production (0.572), stem fresh weight (0.565), leaf fresh weight (0.525), leaf dry weight (0.515), number of leaves (0.504), stem dry weight (0.499), leaf area index (0.463), number of branches (0.443), plant height (0.334), crude fibre (0.242) and leaf stem ratio (0.214) had significant positive correlation with production efficiency.

4.4.2.15 Crude protein

Crude protein showed significant positive correlation with dry fodder yield (0.256), days to first flowering (0.254), days to 50% flowering (0.241) and stem fresh weight (0.222).

4.4.2.16 Crude fibre

Crude fibre had significant positive correlation with leaf area index (0.403), plant height (0.287), green fodder yield (0.255), dry matter production (0.246), production efficiency (0.242), stem fresh weight (0.227) and leaf fresh weight (0.214).

4.4.2.17 Dry matter production

Dry matter production showed significant positive correlation with dry fodder yield (0.712), leaf dry weight (0.652), leaf area index (0.638), stem dry weight (0.589), production efficiency (0.572), green fodder yield (0.553), leaf fresh weight (0.497), plant height (0.437), stem fresh weight (0.42), number of leaves (0.387), number of branches (0.377), leaf stem ratio (0.281) and crude fibre (0.246) whereas days to 50% flowering (-0.238) had negative correlation with dry matter production.

4.5 PATH COEFFICIENT ANALYSIS

Path coefficient analysis was used to partition observed correlation coefficients between dependent variable green fodder yield and its component traits into direct and indirect effect. The results obtained from present study for direct and indirect effect are presented character wise in Table 9.

4.5.1 Direct effects

Path coefficient of different traits on green fodder yield revealed that production efficiency (0.866) had highest positive direct effect on green fodder yield. Leaf dry weight (0.291), plant height (0.241), number of leaves (0.229), crude protein (0.067), leaf fresh weight (0.058), leaf stem ratio (0.041) and number branches (0.001) showed direct positive effect on green fodder yield. Negative direct effect was exhibited by the traits dry fodder yield (-0.356), stem fresh weight (-0.105), stem dry weight (-0.083), crude protein (-0.068), crude fibre (-0.003) and leaf area index (-0.003). (Fig. 5)

4.5.2 Indirect effect

4.5.2.1 Plant height

Plant height had indirect positive effect on green fodder yield through production efficiency (0.669), leaf dry weight (0.152), number of leaves (0.115), leaf fresh weight (0.0276), crude protein (0.0128), leaf stem ratio (0.0092) and number of branches (0.0002), crude fibre (-0.0009), leaf area index (-0.0015), dry matter production (-0.0372), stem fresh weight (-0.0934) and dry fodder yield (-0.2294) showed negative indirect effect on green fodder yield.

4.5.2.2 Number of branches

Number of branches was observed to have indirect positive effect on green fodder yield through production efficiency (0.7604), leaf dry weight (0.2069), number of leaves (0.1732), plant height (0.093), leaf fresh weight (0.0360), leaf stem ratio (0.0192) and crude protein (0.0066). Indirect negative effect was shown by the characters dry fodder yield (-0.2742), stem dry weight (-0.0596), stem fresh weight (-0.0556), dry matter production (-0.0462), leaf area index (-0.0012) and crude fibre (-0.0006).

Table 9. Direct and indirect effect yield attributing characters on fodder rice bean

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	**0.214**	0.00025	0.1150	0.0276	-0.0934	0.1525	-0.0440	-0.2294	-0.0015	0.0092	0.6695	0.0128	-0.0009	-0.0372
X2	0.0938	**0.001**	0.1732	0.0360	-0.0556	0.2069	-0.0596	-0.2742	-0.0012	0.0192	0.7604	0.0066	-0.0006	-0.0462
X3	0.1213	0.00049	**0.229**	0.0540	-0.0723	0.1418	-0.0496	-0.2266	-0.0015	0.0102	0.8721	0.0177	-0.0004	-0.0392
X4	0.1153	0.00040	0.2141	**0.058**	-0.0848	0.2058	-0.0654	-0.3005	-0.0015	0.0121	0.7735	0.0176	-0.0007	-0.0444
X5	0.2139	0.00034	0.1570	0.0465	**-0.105**	0.1514	-0.0508	-0.2594	-0.0016	0.0067	0.9126	0.0073	-0.0013	-0.0542
X6	0.1266	0.00549	0.1116	0.0409	-0. 0549	**0.291**	-0.0618	-0.3208	0.0020	0.0290	0.6737	0.0079	-0.0007	-0.0605
X7	0.1288	0.00047	0.1378	0.0458	-0.0649	0.2181	**-0.083**	-0.2383	-0.0016	0.0038	0.8071	0.0082	-0.0006	-0.0568
X8	0.1554	0.00050	0.1455	0.0487	-0.0767	0.2617	-0.0551	**-0.356**	-0.0018	0.0288	0.7897	0.0173	-0.0006	-0.0568
X9	0.1302	0.00027	0.1240	0.0310	-0.0614	0.2058	-0.0478	-0.2287	**-0.003**	0.0209	0.7670	0.0110	-0.0011	-0.0461
X10	0.0541	0.00030	0.0569	0.0170	-0.0172	0.2058	-0.0076	-0.2504	-0.0014	**0.041**	0.2096	0.0051	-0.0005	-0.0377
X11	0.1866	0.00057	0.2305	0.0516	-0.1111	0.2262	-0.0769	-0.3250	-0.0025	0.0099	**0.866**	0.0009	-0.0010	-0.0645
X12	0.0462	0.00006	0.0607	0.0152	-0.0115	0.0344	-0.0102	-0.0921	-0.0004	0.0031	0.0124	**0.067**	0.0002	-0.0042
X13	0.0893	0.00014	0.0385	0.0159	-0.0535	0.0829	-0.0187	-0.0906	-0.0012	0.0080	0.3506	-0.0057	**-0.003**	-0.0174
X14	0.1323	0.00044	0.1321	0.0377	-0.0841	0.2593	-0.0658	-0.2980	-0.0019	0.0228	0.8230	0.0041	-0.0006	**-0.068**

X1- Plant height

X2- Number of branches

X3- Number of leaves

X4-Leaf fresh weight

X5- Stem fresh weight

X6-Leaf dry weight

X7-Stem dry weight

X8-Dry fodder yield

X9-Leaf area index

X10-Leaf stem ratio

X11- Production efficiency

X12-Crude protein

X13-Crude fibre

X14- Dry matter production

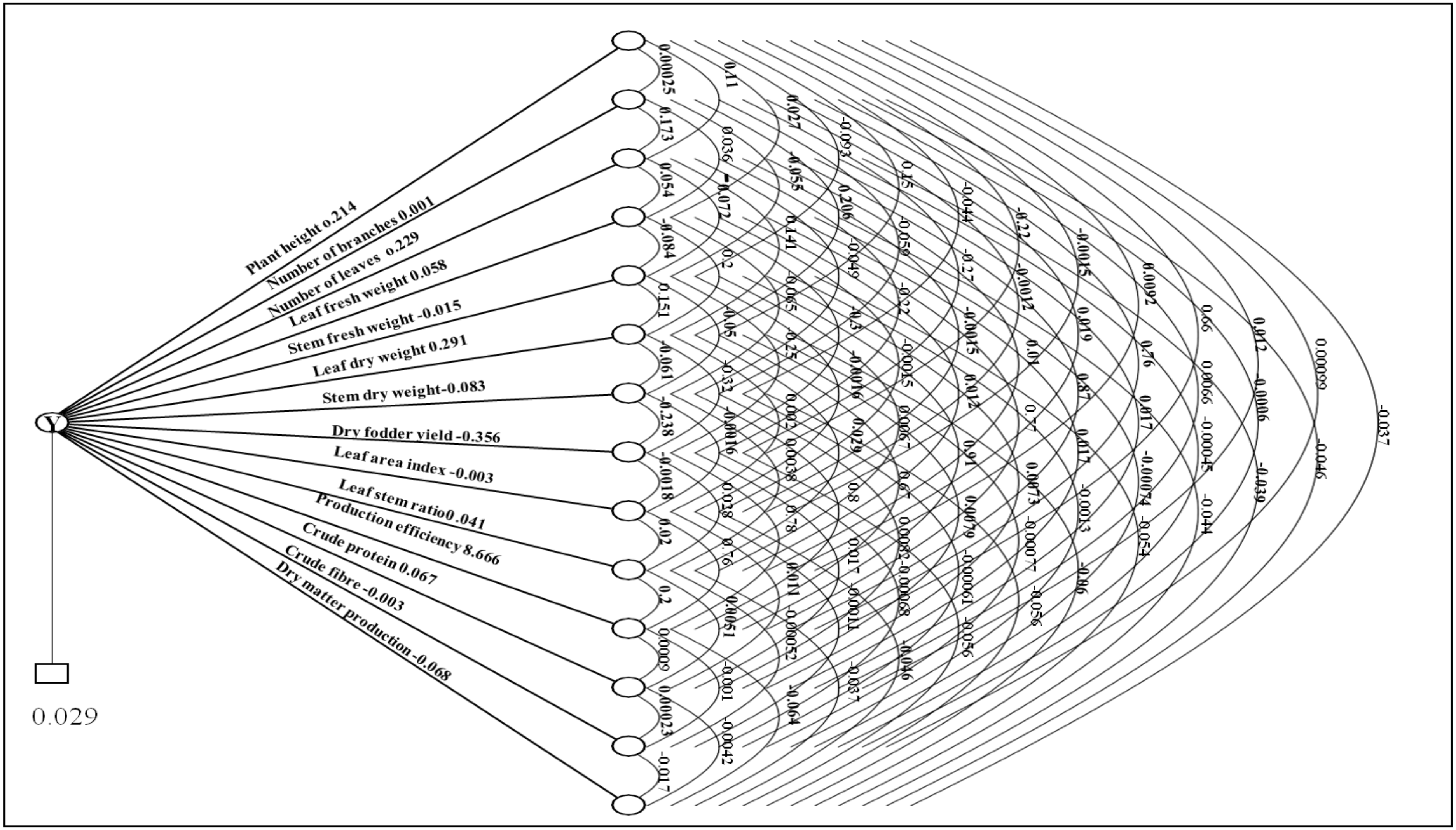

Fig 5. Path diagram showing direct and indirect effect of component characters on green fodder yield

4.5.2.3 Number of leaves

Number of leaves showed indirect positive effect on green fodder yield through production efficiency (0.8721), leaf dry weight (0.1418), plant height (0.1213), leaf fresh weight (0.0540), crude protein (0.0177), leaf stem ratio (0.0102) and number of branches (0.0004). Characters dry fodder yield (-0.2266), stem fresh weight (-0.0723), stem dry weight (-0.0496), dry matter production (-0.0392), leaf area index (-0.0015) and crude fibre (-0.0004) showed negative correlation.

4.5.2.4 Leaf fresh weight

Leaf showed indirect effect on green fodder yield through production efficiency (0.7735), number of leaves (0.2141), leaf dry weight (0.2058), plant height (0.1153), crude protein (0.0176), leaf stem ratio (0.0121) and number of branches (0.0004). Dry fodder yield (-0.3005), stem fresh weight (-0.0848), stem dry weight (-0.0654), dry matter production (-0.0444), leaf area index (-0.0015) and crude fibre (-0.0007) had indirect negative effect on green fodder yield.

4.5.2.5 Stem fresh weight

Production efficiency (0.9126), plant height (0.2139), number of leaves (0.1570), leaf dry weight (0.1514), leaf fresh weight (0.0465), crude protein (0.0073), leaf stem ratio (0.0067) and number of branches (0.0003) showed indirect positive effect on green fodder yield through stem fresh weight. Indirect negative effect was shown by the characters dry fodder yield (-0.2594), dry matter production (-0.0542), stem dry weight (-0.0508), leaf area index (-0.0016) and crude fibre (-0.0013) on green fodder yield through stem fresh weight.

4.5.2.6 Leaf dry weight

Leaf dry weight had indirect positive effect on green fodder yield through production efficiency (0.6737), plant height (0.1266), number of leaves (0.1116), leaf fresh weight (0.0409), leaf stem ratio (0.0290), crude protein (0.0077), number of branches (0.0054) and leaf area index (0.0020). Negative indirect effect on green fodder yield through leaf dry weight was shown by dry fodder yield (0.3208), stem dry weight (-0.0618), dry matter production (-0.0605), stem fresh weight (-0.0549) and crude fibre (-0.0007).

4.5.2.7 Stem dry weight

Stem dry weight was observed to have positive indirect effect on green fodder yield through production efficiency (0.8071), leaf dry weight (0.2181), number of leaves (0.1378), plant height (0.1288), leaf fresh weight (0.0458), crude protein (0.0082), leaf fresh weight (0.0038) and number of branches (0.0004). Dry fodder yield (-0.2383), stem fresh weight (-0.0649), dry matter production (-0.0568), leaf area index (-0.0016) and crude fibre (-0.0006) had indirect negative effect through stem dry weight on green fodder yield.

4.5.2.8 Dry fodder yield

Dry fodder yield showed negative indirect effect on green fodder yield through production efficiency (0.7897), leaf dry weight (0.2617), plant height (0.1554), number of leaves (0.1455), leaf fresh weight (0.0487), leaf stem ratio (0.0288), crude protein (0.0173) and number of branches (0.0005). Stem fresh weight (0.0767), dry matter production (-0.0568), stem dry weight (-0.0551), leaf area index (-0.0018) and crude fibre (-0.0006) had indirect negative effect through dry fodder yield on green fodder yield.

4.5.2.9 Leaf area index

Leaf area index was observed to have indirect positive effect on green fodder yield through production efficiency (0.7670), leaf dry weight (0.2058), plant height (0.1342), number of leaves (0.124), leaf fresh weight (0.031), leaf stem ratio (0.0209), crude protein (0.0110) and number of branches (0.0002). Dry fodder yield (-0.228), stem fresh weight (-0.0614), stem dry weight (-0.0478), dry matter production (-0.0461) and crude fibre (-0.0011) had indirect negative effect through leaf area index.

4.5.2.10 Leaf stem ratio

Leaf stem ratio showed indirect positive effect on green fodder yield through production efficiency (0.2096), leaf dry weight (0.2058), number of leaves (0.0569), plant height (0.0541), leaf fresh weight (0.0170), crude protein (0.0051) and number of branches (0.0003). Negative indirect effect through leaf stem ratio was shown by the characters dry fodder yield (-0.2504), dry matter production (-0.0377), stem fresh weight (-0.0172), stem dry weight (-0.0076), leaf area index (-0.0014) and crude fibre (-0.0005).

4.5.2.11 Production efficiency

Production efficiency had indirect positive effect on green fodder yield through number of leaves (0.2305), leaf dry weight (0.2262), plant height (0.1866), leaf fresh weight (0.0516), leaf stem ratio (0.0099), crude protein (0.0009) and number of branches (0.0005). Characters dry fodder yield (-0.3250), stem fresh weight (0.1111), stem dry weight (-0.0769), dry matter production (-0.0645), leaf area index (-0.0025), and crude fibre (-0.0010) showed indirect negative effect through production efficiency.

4.5.2.12 Crude protein

Indirect positive effect on green fodder yield through crude protein was shown by the characters number of leaves (0.0607), plant height (0.0462), leaf dry weight (0.0344), leaf fresh weight (0.0152), production efficiency (0.0124), leaf stem ratio (0.0031), crude fibre (0.0002) and number of branches (0.00006). Characters dry fodder yield (-0.0921), stem fresh weight (-0.0115), stem dry weight (-0.0102), dry matter production (-0.0042) and leaf area index (-0.0004) showed indirect negative effect through crude protein on green fodder yield.

4.5.2.13 Crude fibre

Crude fibre showed indirect positive effect on green fodder yield through production efficiency (0.3506), plant height (0.089), leaf dry weight (0.0829), number of leaves (0.0385), leaf fresh weight (0.0159), leaf stem ratio (0.0080) and number of branches (0.0001). Dry fodder yield (-0.0906), stem fresh weight (0.0535), stem dry weight (-0.0187), dry matter production (-0.0174) and crude protein (-0.0057) had indirect negative effect through crude fibre.

4.5.2.14 Dry matter production

Dry matter production showed indirect positive effect through production efficiency (0.8230), leaf dry weight (0.2593), plant height (0.1323), number of leaves (0.1321), leaf fresh weight (0.0377), leaf stem ratio (0.0228), crude protein (0.0041) and number of branches (0.0004). Indirect negative effect on green fodder yield through dry matter production was shown by the characters dry fodder yield (0.2980), stem fresh weight (-0.0841), stem dry weight (-0.0658), leaf area index (0.0019) and crude fibre (-0.0006).

Residual effect found was 0.02981.

4.6 CLUSTER ANALYSIS

D^2 statistics proposed by Mahalanobis has been used to study D^2 statistics on thirty genotypes of rice bean over seventeen yield and yield contributing characters. Results obtained are presented below (Fig.6)

4.6.1 Grouping of genotypes into different clusters

Based on D^2 values thirty genotypes were grouped into five clusters following Tocher's method. The cluster I contain 12 genotypes, followed by cluster III which has 10 genotypes, cluster IV with 4 genotypes, cluster II with 3 genotypes and cluster V with 1 genotype. Cluster wise distribution of genotypes is summarized in Table 10.

4.6.2. Intra and Inter cluster D^2 values

The average intra and inter-cluster D^2 values were calculated and presented in the Table 11.

Average intra cluster distance was ranged from 11.09 to 0.00. Highest intra cluster divergence was observed in the cluster III followed by IV (10.35), II (10.22) and I (9.29).

Table10. Distribution of rice bean genotypes in different clusters

Cluster No	Number of genotypes	Genotypes
I	12	IC19338, IC521116, IC521143, IC521149, EC98452, IC469192, IC521152, IC341997, IC521350, IC521150, EC18260 , IC341998
II	3	IC18456, IC521122, IC521123
III	10	IC341986, IC469195, IC521128, IC521114, IC521134, IC341991, IC521119, IC521115, IC18553, IC521145
IV	4	IC15640, IC18465, EC16136, IC8565-3
V	1	IC2567

Table 11. Average intra and inter-cluster D^2 values

Cluster No	**I**	**II**	**III**	**IV**	**V**
I	**9.29**	14.81	13.40	13.23	19.36
II		**10.22**	22.88	16.32	12.61
III			**11.09**	18.52	27.47
IV				**10.35**	16.70
V					**0.00**

The highest inter cluster distance was observed between the genotypes of cluster III and IV (27.47), followed by cluster II and III (22.88), I and V (19.36), III and IV (18.52), IV and IV (16.70), II and IV (16.32), I and II (14.81), I and III (13.40), I and IV (13.23) whereas least divergence was observed between the cluster II and V. (Fig. 6)

Cluster I (9.29) was poly-genotypic and nearest to cluster IV (13.23), and cluster IV (13.23), followed by cluster II (14.81) and V (19.36). Cluster II (14.81) was found to be nearest to the clusters V (12.61) followed by the clusters II (14.81), IV (16.32) and III (22.88). Cluster III was found to be poly-genotypic and nearest to the cluster III (13.40) followed by the cluster IV (18.52), II (22.88) and V (27.47). Cluster IV (10.35) showed least divergence with the clusters I (13.23) followed by II (16.32), V (16.70) and III (18.52). Cluster V was mono-genotypic and showed least distance with the cluster II (12.61) followed by the cluster IV (16.70), I (19.36) and III (27.47).

4.6.3 Mean value of different cluster

Table 12 revealed that genotypes accommodated under cluster IV were found to flower first with average value of 38.42 days followed by cluster III (38.47), I (38.53), II (38.42) and V (40.33). Maximum number of days to 50% flowering was recorded by the genotypes accommodated under cluster V with average value of 50 days followed by the clusters II (49.00), III (48.90), I (48.36) and IV (48.33). Highest plant height was observed in the genotypes falling under the cluster III (127.51), least plant height was observed in the genotypes of cluster V (101), whereas cluster I, II and IV recorded 119.26, 115.78 and 115.67 days respectively. Maximum number of branches was observed in the genotypes accommodated under the cluster IV (4.82) followed by III (4.58), I (4.23) and II (4.03), lowest number of branches was observed in the genotypes falling under the cluster IV (3.33). Highest number of leaves was recorded in the genotypes falling under the cluster III (27.27), I (25.46), 1V (25.32), II (24.49), least number of branches was observed in the genotypes falling under the cluster IV (21.33). Leaf fresh weight was found to be high in the genotypes falling under the cluster III (190.43) followed by I (162.92), IV (152.83), II (142.00) whereas genotypes accommodated under the cluster V (115.00) recorded lowest leaf fresh weight. Maximum stem fresh weight was recorded in the genotypes falling under the

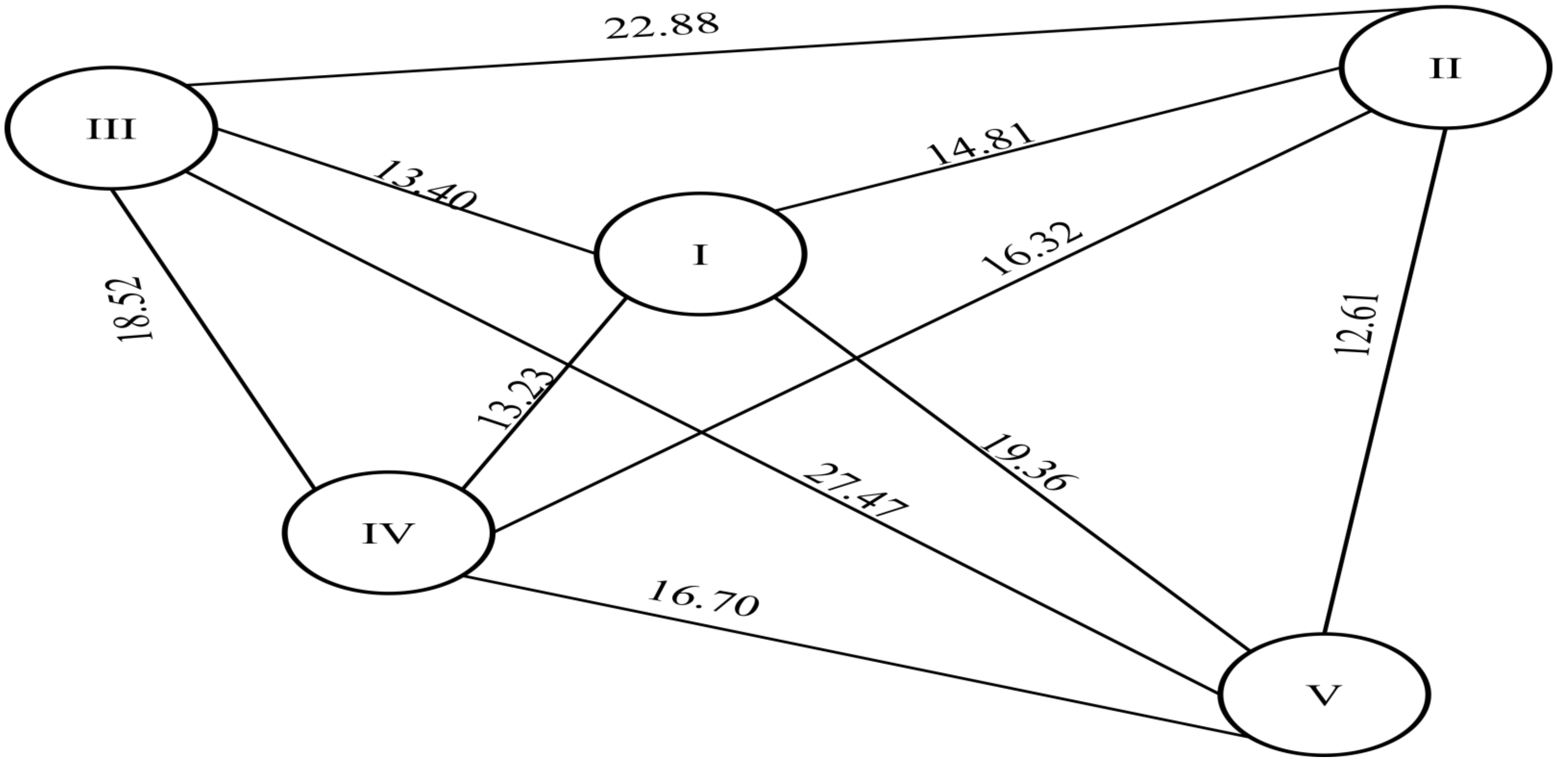

Fig 6. Averge inter cluster distance between different clusters of fodder rice bean

cluster III (251.23) followed by the cluster I (237.97), II (216.63), IV (214.00) where as lowest value was recorded from the genotypes falling under the cluster V (172.00). Highest green fodder yield was recorded in the genotypes falling under the cluster III (435.50) followed by I (384.64), II (358.19), IV (377.17) whereas green fodder yield was found to be lowest in the genotypes accommodated under the cluster V (303.67). Highest leaf dry weight was observed in the genotypes of the cluster III (30.20) followed by IV (25.50), I (24.31), II (18.67), least leaf dry weight was observed in the genotypes of the cluster V (12.67). Stem dry weight was observed to have highest in the genotypes of the cluster III (43.43), medium values was observed in the genotypes of the cluster IV (39.67), I (38.83), lowest stem dry weight was observed in the genotypes of the cluster V (30.00) and II (31.11). Maximum dry fodder yield was observed in the genotypes of the cluster III (70.80), followed by IV (59.50), I (57.78), minimum dry fodder yield was observed in the genotypes of the cluster V (40.00) and II (42.00). Leaf area index was found to be maximum for the genotypes of the cluster III (4.22) and I (3.36), medium value was recorded in the genotypes of the cluster IV (2.85), least value of leaf area index was observed in the genotypes of the cluster V (2.46) and II (2.62). Highest leaf stem ratio was observed in the genotypes of the cluster IV (0.71) and III (0.70), medium leaf stem ratio was observed in the genotypes falling under the cluster I (0.63) and II (0.61), least value of leaf stem ratio was observed in the genotypes of the cluster V (0.42). Production efficiency was found to be highest in the genotypes of the cluster III (8.93), followed by I (7.98), IV (7.82) and II (7.31), minimum value was recorded from the genotypes of the cluster V (6.12). Highest crude protein content was observed in the genotypes of the cluster V (18.10) followed by III (17.70) and I (17.15) minimum value was recorded from the genotypes of the cluster IV (15.68) and II (15.84). Highest crude fibre was recorded from the genotypes of the cluster III (5.52) followed by I (5.39) and II (5.36). Minimum crude fibre percentage was recorded from the genotypes of the cluster V (2.80) and IV (3.57). Highest dry matter production was recorded from the genotypes of the cluster III (80.36) followed by IV (72.79) and I (69.50), minimum value was recorded from the genotypes of the cluster V (46.26) and II (49.42).

Table 12. Cluster mean values showing importance of grouped characters

Cluster No.	Days to first flowering (Days)	Days to 50% flowering (Days)	Plant height (cm)	Number Branches (cm)	Number of leaves	Leaf fresh weight (t/ha)	Stem fresh weight (t/ha)	Green fodder yield (t/ha)	Leaf dry weight (t/ha)	Stem dry weight (t/ha)	Dry fodder yield (t/ha)	Leaf area index	Leaf stem ratio	Production efficiency (t/ha)	Crude protein (%)	Crude fibre (%)	Dry matter production (t/ha)
I	38.53	48.36	119.26	4.23	25.46	162.92	237.97	384.64	24.31	38.83	57.78	3.36	0.63	7.98	17.15	5.39	69.50
II	39.22	49.00	115.78	4.03	24.49	142.00	216.63	358.19	18.67	31.11	42.00	2.62	0.61	7.31	15.84	5.36	49.42
III	38.47	48.90	127.51	4.58	27.27	190.43	251.23	435.50	30.20	43.43	70.80	4.22	0.70	8.93	17.70	5.52	80.36
IV	38.42	48.33	115.67	4.82	25.32	152.83	214.00	377.17	27.50	39.67	59.50	2.85	0.71	7.82	15.68	3.57	72.79
V	40.33	50.00	101.23	3.33	21.33	115.00	172.00	303.67	12.67	30.00	40.00	2.46	0.42	6.12	18.10	2.80	46.26

DISCUSSION

5. DISCUSSION

Livestock sector is the main stay of Indian economy and integral part of Indian agriculture, supporting livelihood of more than two-third of rural population and main source of income for small and marginal farmers. Livestock sector faces fodder and feed scarcity, which can be overcome by cultivation of quality fodder crops. Nowadays leguminous crops are emerging as nutritious animal fodder, rice bean is one of important leguminous fodder with high protein content is known to increase milk production in livestock.

In the present investigation “Genetic analysis in fodder rice bean for yield and quality” conducted at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, thirty diverse fodder rice bean genotypes were evaluated. Success of any breeding program depends on presence of genetic variability in the breeding population. Variability must be genetic and variable in nature. The salient findings of the present investigation are interpreted and presented in this chapter in light of available literature published. The results obtained from the investigation are discussed in this chapter.

5.1 ANALYSIS OF VARIANCE

In the present investigation, seventeen characters were studied for thirty genotypes, in which all the characters showed considerable variation among genotypes. The ANOVA indicated that the mean sum of square due to genotypes were highly significant for the characters, days to first flowering, plant height, number of branches, number of leaves, leaf fresh weight, stem fresh weight, green fodder yield, leaf dry weight, stem dry weight, dry fodder yield, leaf area index, leaf stem ratio, production efficiency, crude protein, crude fire and dry matter production whereas it was found to be non-significant for the character days to 50% flowering. Similar result was obtained by Gupta (2016) in rice bean, Fikreselassie and Seboka (2012) in faba bean.

5.2 MEAN PERFORMANCE

Mean performance of seventeen traits for thirty genotypes of fodder rice bean were worked out. Mean values for all the character differed with genotypes.

Days to first flowering varied from 34 DAS to 41 DAS. Minimum number of days was taken by the genotype IC8565-3 and maximum number of days was taken by the genotype IC521152. Days to flower initiation was ranged from 112 days to 169 days in a study conducted by Kujur (2016) in rice bean. Number of days to attain 50% flowering was ranging from 47 DAS to 50.33 DAS, genotypes IC15640, IC19338, IC341991 and IC469195 had taken less number of days to reach 50% flowering. Day to 50% flowering had ranges from 53 days to 71 days in a study conducted by Gupta (2016) in rice bean.

Plant height varied from 145.06 cm to 101.23 cm, maximum plant height was observed in the genotype IC521119. Variation in plant height among different genotypes might be due to different growth behaviour or due to their genetic constitution. Inherent genetic material decides the performance of genotypes. Borah (1999) recorded highest plant height of 77 cm in rice bean. In rice bean, mean plant height of 84.21 cm to 264.08 cm was obtained by Kujur (2016). Plant height range of 80.40 cm to 144.67 cm was recorded in fodder horse gram by George (2019). Alghamdi (2007) reported that plant height ranged between 89 to 108 cm in faba bean.

Highest number of branches was observed in the genotype IC8565-3(5.26) whereas lowest in the genotype EC98452 (3.33). In rice bean, Ahirwal (2011) reported mean value of 5.85 for number of branches. Numbers of branches were varying from 4.8 to 8.9 in a study conducted by Neelam *et al*. (2014) in fodder horse gram.

Number of leaves per plant had ranges from 20.47 to 32.4 with maximum numbers of leaves observed in the genotype IC521134 and minimum number of leaves was observed in the genotype IC341998. Maximum number of leaves will result in maximum leaf fresh weight, which in turn increases green fodder yield and dry fodder yield. Numbers of leaves per plant had ranges from 14 to 39 in a study conducted by Jharia

(2007) in rice bean. Prakash *et al*. (2010) in fodder horse gram reported that number of leaves varies from 46 to 55.

Leaf area index is the ratio of projected area of leaves over unit of land and it is the measure of the active photosynthetic area. Leaf area index had ranged between 2.15 to 4.64, highest value recorded in the genotype IC18553 (4.64) and lowest in the genotype IC18456 (2.15). Leaf area index between 2.81 to 4.06 was reported in fodder rice bean by Aswathi (2016). Leaf area of about 2.09 was observed in fodder cowpea in a study conducted by Kurubetta (2006).

Leaf stem ratio was computed by dividing the dry weight of leaves by dry weight of stem. Highest leaf stem ratio was reported by the genotype IC521114 (0.82) and least by the genotype EC98452 (0.42). Leaf stem ratio had ranged between 0.65 to 1.51 in a study conducted by Jharia (2007). Similar result was obtained by Dogra (2006) in fodder horse gram.

Green fodder yield was found to be highest for the genotype IC341991 (35.49 t ha^{-1}), maximum leaf fresh weight and stem fresh weight were responsible for highest green fodder yield. Least for the genotype EC98452 (22.32 t $ha^{-1)}$, minimum leaf fresh weight and stem fresh weight lead to lowest green fodder yield. Green fodder yield of about 81 gram per plant to 167 gram per plant was obtained by (Jharia, 2007) in study conducted in rice bean.

Dry fodder yield was found to be highest in the genotype which was having high green fodder yield i.e. IC341991 (6.27 t ha^{-1}) and lowest in the genotype which was having lowest green fodder yield i.e. EC98452 (2. 94 t ha^{-1}). Similar result was obtained by Bakhsh *et al*. (2007) in fodder oat.

Highest Dry matter production was recorded from the genotype IC341991 (6.972t ha^{-1}), lowest in the genotype IC521123 (3.274 t ha^{-1}). Highest green and dry fodder yield would have directly contributed to maximum dry matter production. Similar result was obtained by Gupta (2016). Singh *et al*. (1999) reported dry matter production of 50.10 q ha^{-1} in fodder cow pea. Rudragowda and Angadi (2002) also reported similar findings in rice bean.

Production efficiency is obtained by dividing total green fodder yield by number of days to harvest. It provides information about biomass produced per plant per day. Production efficiency had values ranged between 0.450 t ha^{-1} to 0.755 t ha^{-1}, highest production efficiency was reported by the genotype IC341991 (0.755 t ha^{-1}) and lowest by the genotype EC98452 (0.450 t ha$^{-1)}$. Production efficiency is the key factor which determines the yield of any fodder crop. Production efficiency of about 0.11 t ha^{-1} to 0.25 t ha^{-1} was recorded in a study conducted by George (2018) in fodder horse gram.

Crude protein content had varied significantly with the genotype. It varies between13.30% to 21%. Highest was recorded in the genotype IC521119 (21%) and lowest was recorded for the genotype IC18553 (13.30%). Crude protein is one of the important parameter which determines the quality of green fodder. Highest nitrogen uptake by the plant will result in more crude protein content in that variety (Iqbal, 1998). Crude protein content of about 15.64% was recorded in a study conducted by Aswathi, (2016) in fodder rice bean.

Crude fibre content had ranged between 2.8% to 6.7%. Highest crude fibre content was recorded for the genotype IC469192 (6.7%) and lowest for the genotype EC98452 (2.8%). It is one of the most important quality parameter which influences the digestibility of the fodder. Less crude fire content leads to more palatability to the animals. Crude fibre content of about 19.77% was reported in rice bean by a study conducted by Gupta (2016).

5.3 PARAMETERS OF GENETIC VARIABILITY

The main objective of present investigation was to study the genetic variability in thirty genotypes of rice bean. Information on genetic component variability is useful in deciding selection criteria for genetic improvement of complex trait yield in fodder rice bean. Genetic component of variation is very important for selection of elite genotypes.

Presence of genetic variability is important for success of any plant breeding program, it provides opportunity for plant breeder to use his knowledge and skill in making correct selection. The mean sum of square of seventeen quantitative characters has been presented in the Table 2.

5.3.1 Phenotypic and Genotypic coefficient of variation

Phenotypic and genotypic coefficient of variation measures the amount of variability present in a population. PCV measures the extent of total variation present in a population and it is equal to sum total of GCV and environmental effects.GCV represents heritable component of variation present in plant population. Phenotypic and Genotypic coefficient of variation for various quantitative characters under study has been presented in the Table 6. From the table it is evident that phenotypic coefficient of variation is more than genotypic coefficient of variation for all the seventeen character under study, indicating variable influence of environment on expression of characters (Fig.3). High GCV and PCV values were reported for the characters crude fibre and dry fodder yield, due to highest GCV we can go for direct selection of these characters. Similar result was obtained by Borah and Khan (2000) for leaf stem ratio and dry fodder yield in fodder cowpea. High GCV for leaf area index was obtained by Thorat and Gadewar (2013) in fodder cowpea. Borah and Khan (2000) reported same result in fodder cowpea for the characters number of branches, number of leaves, leaf stem ratio, green fodder yield and dry fodder yield.

Moderate values of GCV and PCV were reported for the characters dry matter production, stem dry weight and crude protein. Moderate GCV and high PCV values were reported for the characters leaf fresh weight, leaf area index, leaf stem ratio, stem fresh weight and leaf dry weight. Similar results was obtained by Kumar, *et al*. (2017) in rice bean. Aravindhan and Das (1995) and Ponmariammal and Das (1996) had reported similar result in fodder cowpea.

Low GCV and moderate PCV values were observed for the characters number of branches, number of leaves, green fodder yield and production efficiency whereas minimum values of GCV and PCV were observed for the characters days to first flowering, days to 50% flowering, plant height, number of branches, number of leaves, green fodder yield and production efficiency.Similar result was obtained by Chaudhari *et al*. (2000) in rice bean and Mehta *et al*. (2007) in fodder soya bean.

5.3.2 Heritability and Genetic advance

Heritability and genetic advance are the two important factors which determine the effectiveness selection in any crop improvement programme. High heritability coupled with high genetic advance indicates presence of additive gene and increased heritability of concerned trait. Heritability estimates permits greater effectiveness of selection by partitioning the environmental influence from total variability and it indicates accuracy with which a genotype can be identified phenotypically.

In the present investigation high heritability coupled with high genetic advance was observed for the characters dry matter production, crude fibre, leaf area index, crude protein and dry fodder yield. This indicates that characters are governed by additive gene action and can go for direct selection. High heritability and moderate genetic advance was reported for the character plant height whereas moderate heritability and high genetic advance was reported for the characters leaf fresh weight, leaf dry weight and stem dry weight. Similar result was obtained by Kumar *et al* (1997), Singh *et al*.(1997) and Bhaskar *et al*. (2014) for plant height, Aditya *et al*. (2011) for dry matter yield and Kumar *et al*. (2017) for crude protein. Santhoshkumar *et al*. (2002) reported high heritability and genetic advance for the characters green fodder yield, plant height and dry fodder yield in cowpea. Nath and Tajane, (2014) reported similar result for the characters green fodder yield, dry matter yield, plant height and number of branches in cow pea

Similar result was also obtained by Prashanthi (2004) in fodder cowpea and Mehta *et al*. (2007) in fodder soya bean. Low heritability with moderate genetic advance was reported for the character leaf stem ratio, stem fresh weight, green fodder yield, number of leaves and production efficiency whereas low heritability and genetic advance was reported for the characters days to 50% flowering, days to first flowering and number of branches

5.4 CORRELATION STUDIES

Correlation studies provide information about nature and magnitude of relation between the various quantitative characters which contributes to complex trait yield. Correlation between the characters may be positive or negative. The correlation can be found out at both genotypic level and phenotypic level. Genetic correlation often arises due to linkage or pleiotropy. Degree of association between two variables is measured in terms of correlation co-efficient. Correlation studies helps in selection of traits which will not show direct positive correlation with yield, such character have indirect positive effect through other component characters; hence selection of such traits helps in improvement of yield.

In the present investigation, characters such as number of leaves, stem fresh weight, production efficiency, stem dry weight, leaf area index, dry fodder yield, leaf fresh weight, dry matter production, number of branches, plant height, leaf dry weight, crude fibre and leaf stem ratio showed positive correlation with green fodder yield. Selection of these characters will results in simultaneous improvement of all other correlated characters due to positive correlation.

Study on twenty elite cowpea genotypes by Kumar *et al*. (2017) reported that green fodder yield showed positive correlation with number of branches per plant. Aravindhan and Das (1995) in fodder cowpea inferred that fodder yield had significant positive correlation with number of branches per plant, leaf area index, dry matter yield and crude protein yield. Similar result was also reported by Trehan *et al*. (1970), Chopra and Singh (1977), Tyagi *et al*. (2000), Sharma *et al*. (1991), Chaudhary *et al*. (2000), Pol *et al*. (2001), Dodke and Dohat (2011) for number of branches per plant. Pol *et al*. (2001) for number of leaves per plant and dry matter yield.

5.5 PATH COEFFICIENT ANALYSIS

Path coefficient analysis is one of the important techniques used for plant selection, it is a standardized partial regression coefficient which splits the correlation coefficients into measures of direct and indirect effect and it also measures the cause and association between two variables. There are mainly three types of path coefficients phenotypic, genotypic and environmental path, which are worked out from their respective correlation coefficients (Fig 5).

In the present investigation green fodder yield is kept as dependent variable whereas other traits viz. plant height, number of branches, number of leaves, leaf fresh weight, stem fresh weight, leaf dry weight, stem dry weight, leaf area index, leaf stem ratio, crude protein, crude fibre, dry matter production and production efficiency are considered as independent characters. The characters production efficiency, leaf dry weight, plant height, number of leaves, crude protein, leaf fresh weight, leaf stem ratio and number branches showed direct positive effect on green fodder yield.

Direct selection of these traits will be rewarding. The characters dry fodder yield, stem fresh weight, stem dry weight, crude protein, crude fibre and leaf area index had negative direct correlation with green fodder yield but showed indirect positive correlation with green fodder yield through other component characters viz. plant height, number of branches, number of leaves, leaf fresh weight, leaf dry weight, leaf stem ratio, production efficiency and dry matter production.

Simultaneous selection of all the characters which have positive effect on fodder yield will result genetic improvement of fodder yield. Similar result was reported by Sonone *et al*.(1999) for days to 50% flowering in rice bean, Mehta *et al*. (2007) for dry fodder yield per plant, dry fodder yield per day, protein yield, number of branches, protein yield per day in soya bean; Borah and Khan (1999) for dry matter yield, number of leaves, days to 50% flowering in fodder cowpea; Kumar and Mishra (1981) for dry matter yield in fodder cowpea; Kohli (2002) for number of branches in forage soya bean.

5.6 CLUSTER ANALYSIS

Knowledge of genetic divergence between the hybridizing species is very important in order to develop high yielding superior hybrid variety. The more diverse the parental genotype, chances of producing heterotic effect will be more in hybrid. Assessment of genetic diversity is essential to know extent of diversity present in the population. Mahalanobis D^2 statistics is one of the powerful techniques used to quantify degree of divergence between the genotypes.

In the present investigation thirty genotypes of fodder rice bean were considered for assessing genetic diversity.

5.6.1 Group constellations

Thirty genotypes of rice bean were grouped into five clusters based on D^2 values following Tocher's method. Cluster I is the largest cluster having 12 genotypes followed by cluster III (10 genotypes), cluster IV (4 genotypes), cluster II (3 genotypes) and cluster V (1 genotype).

Murthy and Arunachalam (1966) explained that such a wide adaptability could be possible due to reason such as heterogeneity genetic architecture of the population, past history of selection, developmental factors degree of Genetic Combining Ability (GCA). This indicates that there is considerable variability existing among the genotypes of that cluster.

In rice bean, Singh *et al*. (1999) grouped 31genotypes of rice bean into five clusters, Nagalakshmi *et al*. (2010) grouped 66 genotypes of fodder cowpea into 23 clusters and Basavaprabhu *et al*. (2013) grouped 49 genotypes of rice bean into 5 clusters.

5.6.2 Intra and Inter cluster divergence

Highest intra cluster distance was observed in the genotypes falling under the cluster III followed by cluster IV, II and I whereas intra cluster distance was found to be zero in the cluster V, because it contains only one genotype.

Angadi, (1976) reported that variability in the cluster with the high order of divergence among themselves would be the best breeding material for achieving maximum genetic advance with regard to yield.

Maximum inter cluster distance was observed between the genotypes of the cluster III and V, followed by II and III, I and V, III and IV, II and IV whereas minimum inter cluster distance was observed between the genotypes of the cluster II and V followed by I and IV, I and III.

Grouping indicated that some genotypes belonging to the same location got segregated into different clusters and certain genotypes habituating in different locations got grouped into the same cluster this leads to the inference that factor other than geographical diversity may be responsible for such clustering and that in to parallelism between geographical distribution and genetic diversity .

Similar findings were reported by Roquib and Das (1995), Singh *et al*. (1999), Seehalak *et al*. (2006), Sahu *et al*. (2007) and Sarkar and Bhattacharya (2007).

SUMMARY

6. SUMMARY

Profound knowledge on variability present in the genetic material is very important in all breeding program. Introduction of new genotypes to different regions is one of the ways to increase variability. The present investigation ‘Genetic analysis in fodder rice bean for yield and quality’ was conducted at Department of Plant Breeding and Genetics, Collage of Agriculture, Vellayani, during 2019-20 with an objective to identify high yielding superior verities of rice bean for fodder yield and quality .

30 genotypes of fodder rice bean collected from NBPGR were evaluated in Randomized Block Design (RBD) with 3 replication during 2019-20. The seeds were soaked overnight; germinated seeds were dibbled in field, at a spacing 30 x15cm, in plot size of $3m^2$. Harvesting was done at 50% flowering stage, seventeen characters were recorded from the genotypes Viz. days to first flowering, days to 50% flowering, plant height, number of branches, number of leaves, leaf fresh weight, stem fresh weight, green fodder yield, leaf dry weight, stem dry weight, dry fodder yield, leaf area index, leaf stem ratio, production efficiency, crude protein, crude fiber and dry matter production. The character were evaluated by various statistical tools such as analysis of variance, genotypic coefficient of variation (PCV), phenotypic coefficient of variation (GCV), heritability, genetic advance, correlation studies, path analysis and cluster analysis. The most salient results of this investigation are summarized.

On the basis of mean performance, genotype IC341991 was found to be superior in terms of green fodder yield, dry fodder yield, leaf fresh weight, stem fresh weight, leaf dry weight, stem dry weight, dry matter production and production efficiency. Genotype EC98452 recorded lowest value for all yield attributing characters.

All the phenotypic coefficient of variation was greater than the genotypic coefficient of variation for all the characters studied. Highest GCV and PCV were recorded for the characters crude fibre and dry fodder yield. Characters dry matter production, stem dry weight and crude protein recorded moderate GCV and PCV.

Lowest GCV and PCV were observed for the characters days to first flowering, days to 50% flowering, plant height, number of branches, number of leaves, green fodder yield and production efficiency.

Heritability estimates indicates the possibility and extent to which improvement is possible through selection. Ratio of genotypic and phenotypic variance for the traits is called as heritability or it is a heritable portion of phenotypic variance, which has a predictive role in selection procedure. Characters showing higher heritability estimates indicate that, character are less influenced by environment and they are under the influence of more number of fixable factors. Genetic advance is the measure of genetic gain under selection *i.e* improvement in the mean genotypic value of selected plant over the parental population.

High heritability coupled with high genetic advance was recorded for the characters dry matter production, crude fibre, leaf area index, crude protein and dry fodder yield. Due to the presence of additive gene action selection of characters having high heritability and genetic advance will be rewarding for genetic improvement of yield. High heritability and moderate genetic advance was reported for the character plant height whereas moderate heritability and high genetic advance was reported for the characters leaf fresh weight, leaf dry weight and stem dry weight. Low heritability with moderate genetic advance was reported for the character leaf stem ratio, stem fresh weight, green fodder yield, number of leaves and production efficiency whereas low heritability and genetic advance was reported for the characters days to 50% flowering, days to first flowering and number of branches.

Correlation studies gives information about degree and magnitude of relationship between two or more variables. The positive and high value of correlation represent that the characters are in the same direction and high value of one character is associated with high values of others and vice-versa. In the present study characters such as number of leaves stem fresh weight, production efficiency, stem dry weight, leaf area index, dry fodder yield, leaf fresh weight, dry matter production, number of branches, plant height, leaf dry weight, crude fibre and leaf stem ratio had significant positive correlation with green fodder yield. Selection of the characters having maximum correlation with green fodder yield will result in improvement of yield.

In the present investigation characters such as production efficiency, leaf dry weight, plant height, number of leaves, crude protein, leaf fresh weight, leaf stem ratio and number branches had direct positive effect on green fodder yield. Selection of characters of which have direct effect on green fodder yield and also selection of characters which have positive effect on green fodder yield through other component character will result in genetic improvement of yield.

Cluster analysis revealed extent of diversity present in the population. Selection of genotypes from more divergent clusters in the hybridization program will result in maximum heterosis in hybrid. Based on D^2 analysis genotypes were grouped into 5 clusters. Cluster I being the largest contains 12 genotypes followed by cluster III (10 genotypes), cluster IV (4 genotypes), cluster III (3 genotypes) and cluster V (1 genotype). maximum intra cluster distance was recorded in the genotypes of the cluster III and IV whereas highest inter cluster distance was observed in the genotypes of the cluster III and V. Success of breeding program will be high if we select parental genotypes from more divergent population *i.e* genotypes belonging to the cluster having more cluster distance.

The result from the present investigation shows that the genotype IC341991 was found to be superior in terms of yield and yield attributing characters followed by genotypes IC341986, IC521350 and IC521134. We can select these genotypes in hybridisation program for developing high yielding superior fodder varieties of rice bean. Lowest yield was reported for the genotypes EC98452, IC341998 and EC16136. Maximum Crude protein content was recorded for the genotypes IC521119 (21.0%), IC521152 (20.27%) and IC521115 (19.74%) and minimum crude protein content was reported for the genotype IC18553 (13.30%). Crude fibre content was found to be high for the genotype IC469192 (6.7%) and lowest crude fibre content was recorded for the genotypes EC98452 (2.8%).

T_{12}. IC341991

T_{30}. IC521350

T_{11}. IC341986

T_{24}. IC521134

Plate 2. Superior genotypes of fodder rice bean

REFERENCE

7. REFERENCE

Adewale, B. D., Adeigbe, O. O., and Aremu, C. O. 2011. Genetic distance and diversity among some cowpea (*Vigna unguiculata*. L. Walp) genotypes. *Int. J. Res. Plant Sci.* 192):9-14.

Aditya, J.P., Bhartiya, P., and Bhartiya, A. 2011. Genetic variability, heritability and character association for yield and components characters in soya bean (*Glycine max* (L.) Merrill). *J. Central European Agric.* 12(1): 27-34.

Ahirwal. 2011. Genetic analysis of qualitative and quantitative traits in rice bean (*vigna umbellata* (L). Msc thesis. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, 96p.

AICRP (All India Co-ordinated Research Project) on forage crops and utilization.2003. *Annual Report* 2002-2003. Jhansi, 41-43p.

AICRP (All India Co-ordinated Research Project) on forage crops and utilization.2006. *Annual Report* 2005-2006. Jhansi, 243p.

AICRP (All India Co-ordinated Research Project) on forage crops and utilization.2013. *Annual Report* 2012-2013. Jhansi, 123p.

AICRP (All India Co-ordinated Research Project) on forage crops and utilization.2015. *Annual Report* 2014-2015. Jhansi, 76p.

Alghamdi, S. S. (2007). Genetic behaviour of some selected faba bean genotypes. *African Crop Sci. Soc.* 8:709-714.

Angadi, S.B. 1976. Multivariate analysis in cowpea. M.Sc. (Ag) thesis, Tamil Nadu Agricultural University, Coimbatore, 92p.

AOAC (Association of official official Analytical chemist]. 1975. *Off. Tentative Methods anal*. Association of official Analytical Chemist, Washington, D. C, pp. 130-137.

Aravindhan, S. and Das, L.D.V. 1995. Correlation and path analysis for fodder attributes in cowpea. *Madras Agric. J.* 82: 420-422.

Arora, R. K. Chandel, K. P. S., Pant, K. C., and Joshi, BS. 1980. Rice bean-a tribal pulse of Eastern India. *Econ. Bot.* 34(2): 260-263.

Aswathi, E. 2016. Performance of fodder rice bean (*Vigna umbellata*) varieties under varied times of sowing. M.Sc. (Ag) thesis, Acharya N. G. Ranga Agricultural University, Guntur, 103p.

Backiyarani, S. and Nadarajan, N. 1995. Variability and correlation studies on physical characters of primary leaf in cowpea. *Legume Res*. 18(1): 56-58.

Bakhsh, A., Hussain, A., Khan, S., Ali, Z., and Imran, M. 2007. Variability in forage yield of oat under medium rainfall of pothowar tract. *Sarhad J. Agric*. 23:4.

Barthakur, M., Sarma, B. K., Annadurai, A., and Verma, D. K. 2001. Performance of rice bean (*Vigna umbellata*) genotypes in mid-altitude conditions of Meghalaya. *Indian J. hill farming.* 14(1): 150-152.

Basavaprabhu, N.M., Murthy, N., Asif, M., Venkatesh, K.T. and Vijaykumar, K.V. 2013. Genetic divergence analysis in rice bean [*Vigna umbellata* (L.)]. *Legume Res.* 8(1): 166-168.

Bhaskar, V.V., Kachhadia, V.H., Vachhani, J.H., Barad, H.R., Patel, M. B., and Darwankar, M.S. 2014. Genetic variability, heritability, and genetic advance in soya bean (*Glycine max*). *Electr. J. Plant Breed.* 5(4): 802-806.

Borah, H. K. and Khan, A. K. F. 1999. Correlation and path analysis in fodder cowpea. *Crop Res.*18(2) :278-282.

Borah, H. K. and Khan, A.K.F. 2000.variability heritability and genetic advance in fodder cowpea. *Madras Agric*. J. 87(1/3): 165-166.

Borah, U. K. 1994. Response of rainfed rice bean (*Vigna umbellata*) genotypes to varied spacing. *Indian J. Agron.* 39(4): 710-711.

Burton, G. W. 1952. Quantitative inheritance in grasses. *Grass land Cong.* 1:277-288.

Chatterjee, B. N. and Das, P. K. 1989. *Forage Crop Production-Principles and Practices*. Oxford and IBH publishing company, New Delhi, 484p.

Chaudhary, D. P., Saini, R. K., Maurya , B. K., Sharma, M., Kumar, R., Sen, R., and Singh, S.K. 2018. Study of Genetic Variability and Fodder Yield Components in Forage Sorghum (*Sorghum bicolor* L. Moench). *Bull. Enviro. Pharmacology and Life Scie.* 7 (2): 05-09.

Chaudhary, G. B., Patil, J.V. and Barhate, K.K, 2000. Character association in rice bean (*Vigna umbellata*). *Legume Res*. 23:25-28.

Chaudhuri, A. B., Singh, R. P., and Gupta, B. N. 1981. Chemical composition and nutritive value of rice bean straw. *Indian J. Dairy Sci*. 33(4): 438-442.

Chauhan, H. 2017. Study of genetic variability and yield componebts in sweet sorghum. *Forage Res*. 23:212-220.

Cho, N. K., Yun, S. T., Kang, H. S., and Cho, Y. I. 2003. Selection of forage soyabean cultivars in Jeju region. *J. Korea Soci. Grassl. Sci*. 23(4): 299-306.

Chopra, S.K. and Singh, L.N. 1977. Correlation and path analysis in fodder cowpea. *Forage Res*. 3(9): 97-101.

Dagar, J. C. 2017. *Potentials for Fodder Production in Degraded Lands.* In: Ghosh, P. K., Mohanta, S. K., Singh, J. B., Vijay, D., Kumar, R. V., Yadav, V. K., and Sunil, K. (eds) Approaches Towards Fodder Security in India. Studera Press, New Delhi, 364p.

Dash, G. B. 2013.Variability and character association studies among micro mutants of forage rice bean. *Forage Res.* 38(2): 119-121.

Deepthi, V. L., Kalamani, A., and Manivannan, N. 2013. Genetic divergence and association analysis in in Hedge lucern (*Desmanthus virgatus* (L.) Wild). *Electr. J. Plant Breed*. 4(3): 1261-1264.

Devine, P. F., Sawer, C. A., Lane, T. E., Koivisto, J. M. Lane, and Brown, H. J. 2002. Forage soya bean in U. K. : test of new cultivars. *Agron*. 23(4): 287-291.

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.

Dodke, M. M. And Dahat, D. V. 2011. Variability and genetic distance in rice bean. *Asian J. Bio. Sci.* 6(1):79-81.

Dodke, M.M. and Dahat, D.V. 2011. Genotypic and phenotypic variability in rice bean. *Int. J. Plant Sci*. 6(2): 370-371.

Dogra, P. 2006. Genetic divergence for yield and quality attributes in horse gram (*Macrotyloma uniflorum* (Lam.) Verdc.) M.Sc. (Ag) thesis, Chaudhary Swaran Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, 93p.

Falconer, D. S. 1960. *Int. Quant. Genet*. Longman, New York, 160-183.

Fikreselassie, M. and Seboka, H. 2012. Genetic variability on seed yield and related traits of elite faba bean (*Vicia faba* L.) genotypes. *Pakistan J. Biol. Sci.* 15:380-385.

Fisher, R. A. and Yates, F. 1967. Statistical tables for Biological, *Agric. Med. Res*. Olive and Boyd, Edinburgh, 169p.

George, C. 2018. Variability analysis in fodder horse gram (*Macrotyloma uniflorum* (Lam.) Verdc.). Msc thesis, College of Agriculture, Vellayani, Kerala, 94p.

Gerrano, A. S., Adebola,, P. O., Rensburg, W. S. J. C., and Laurie, S. M. 2015. Genetic variability in cowpea (*Vigna unguiculata* (L.) Walp.) genotypes. *South African J. Plant and Soil.* 32(3): 165–174.

Gupta, K. K. 2016. Genetic divergence studies in rice bean [*Vigna umbellata* (L) Thumb]. MSc(Ag) thesis, Birsa Agricultural university, Ranchi, Jharkhand 121p.

IGFRI vision 2050 [Indian Grossland and Fodder Research Institute]. 2015. *IGFRI vision 2050*. Indian Grossland and Fodder Research Institute, Jhansi, 41p.

Iqbal, K., Tanveer, A., Ali, A., Ayub, M., and Tahir, M. 1998. Growth and yield response of rice bean (*Vigna umbellata*) fodder to different levels of N and P. *Pakist. J. Biol. Sci.* 1(3):212-214.

Jain, H. K. 1975. Development of high yielding varieties of pulses; prospective, possibilities and experimental approach. In: *International workshop on grain legume*, ICRISAT, Hyderabad, 17.

Jain, H.K. and Mehra K.L. 1978. Evolution, relationships and uses of species of *vigna* cultivated in India. In: Summerfield and Bunting (Eds). *Adv. Legume Sci*.459-468p.

Jharia, P. 2007.Genetic analysis in Rice bean [*Vigna umbellata* (Thunb) Ohwi and Ohashi]. 2007. MSc(Ag) thesis, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur 142p.

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

Johnson, R. R. 1987. Soya bean: Improvement, production and uses. *Crop manage*. 2: 355-390.

Kapoor, R. and Batra, C. 2014. Genetic variability and association studies in maize (*Zea mays* L.) for green fodder yield and quality traits. *Electr. J. Plant Breed.* 6(1): 233-240.

Katoch, R. D., Priya, B., Kumar, N., and Bhandari, J.C. (2007). Fodder and nutritional attributes of rice bean (*Vigna umbellata*). Range Management and *Agrofor*. 28(2B): 260-262.

Khadka, K. and Acharya, B. D. 2009. *Cultivation Practices of Rice bean* (1st Ed.). Local Initiatives for Biodiversiy Research and Development (LI-BIRD), Nepal, 31p.

Khanal, A. R., Khadka, K., Poudel, I., Joshi, K. D., and Hollington, P. 2009. Report on farmers local knowledge associated with the production, utilization and diversity of rice bean (*Vigna umbellata*) in Nepal. In: *The Rice bean Network: Farmers Indigenous Knowledge of Rice bean in Nepal* (report N 4), EC. FOSRIN (Food security through Rice bean Research in India and Nepal)[on-line].

Available:http://www.ricebean.org/deliverables/deliverable%204%20%20indigenous%20knowledge.pdf=[21 Dec. 2018].

Kohli, K.S. 2002. Variability for fodder yield and its component in cowpea. Range Manage. *Agrofor*. 23(2): 149-151.

Kour, S and Pradhan, U. K. 2016. Genetic variability, heritability, and expected genetic advance for yield and yield components in forage sorghum [*Sorghum bicolour* (L) Moench]. *Rashi* 1(2): 71-76.

Kujur, M. J. 2017. Character association study among components of green fodder yield in rice bean. *Indian J. Agric. Res*. 51 (4): 370-374.

Kujur, M. J., Bilaiya, S. K., Mehta, A. K., and Meena, V. 2017. Genetic divergence in fodder rice bean (*Vigna umbellata*). *Forage Res*. 43(2): 106-109.

Kujur, M. J. 2016. Genetic analysis of important morphological and fodder yielding traits of rice bean. M.Sc. (Ag) thesis, JNKVV, Jabalpur, 85p.

Kumar, A. and Mishra, S.N. 1981. Notes on genotypic variance for forage yield components in cowpea. *Indian J. Agric. Sci*. 51(1): 807-809.

Kumar, B. M. D., Shambulingappa, K. G., Kulkarni, R. S., Swamy, G. S. K., and Lohidhaswa, H. S. 1997. Analysis of genetic variability and character association in rice bean [*Vigna umbellata* (Thunb) Ohwi and Ohashi]. *Mysore J. Agri. Sci.* 31(1):23-28.

Kumar, S. Phogat, D. and Kumari, P. 2017. Genetic parameters for various fodder traits among the elite cowpeas (*Vigna unguiculata*. (L.) Walp.). *Ann. Biol*. 16: 181-183.

Kumar, S., Phogat, D., and Kumari, P. 2017. Genetic parameters for various fodder traits among the elite cowpeas (*Vigna unguiculata* L.Walp) genotypes. *Global J. Bio-Sci. and Bio-technol.* 6 (1): 166-171.

Kurubetta, K. D. 2006. Effect of time of sowing, spacing and seed rate on seed production potentiality and quality of fodder cowpea (*vigna unguiculata*).

M.Sc (Ag) thesis, University of Agricultural Science, Dharwad, Karnataka, 95p.

Lakshmana, D., Jolli, R. B., and Madaiah, D. 2010. Genetic variability studies in rice bean [*vigna umbellata* (Thumb)]. *Legume Res.* 33 (4): 279 –282.

Lawn, R. J. 1995.The Asiativ *Vigna* species.Chapter 65 in smart J and Simmonds, NW (Eds) *Evol. of crop plants*. Second edition. Legume scientific and technical, Harlow, UK. 326p.

Lesly, W. D. And Uma, M. S. 2006. Genetic diversity in cowpea. *Indian J. Plant Genet. Res.* 8(2):153-158.

Livestock census-2012, All India report. Ministry of Agriculture Department of Animal husbandry, Dairying and Fisheries Krishi Bhawan, New Delhi.[online].Available:http://dahd.nic.in/sites/default/filess/Livestock%20%205_0.pdf [19 Mar 2020].

Maan, C. S. 2014. Genetic analysis for forage and quality traits in cowpea [*Vigna unguiculata* (L.) Walp.]. MSc(Ag) thesis. Punjab agricultural university, Ludhiana, 164p.

Malarvizhi, D., Swaminathan, C., Robin, S., and Kannan, K. 2005. Genetic variability studies in fodder cowpea (*Vigna unguiculata* L. Walp). *Legume Res*. (28):52 - 54

Malhopatra, 1973. Genetic variability and discriminant function in soya bean (*Glycine max* L. Merril). *Madras Agric. J.* 60(4): 225-228.

Medhi B. N., Hazarika, M. H., and Choudhary, R. K. 1980. Genetic variability and heritability for seed yield components in green gram. *Trop. grain legume Bull.* 17:32-34.

Mehta, A. K., Vishnoi, R., and Bilaiya, S. K. 2007. Genetic variability in soya bean for green fodder yield and their traits.In; National symposium on “A new vista to forage crop research, kalyani: 10-11th Septmber 2007 BCKV West Bengal, 46p.

Mishra, A., Maduli, K. C., Mishra, B. K. and Paira, A. K. 1995. Interrelationship between yield and its components in rice bean. *Environ. Ecol*. 13(2):430-432.

Mishra, H. P., Ganesh, R., and Jha, P. B. 1994. Correlation and Path coefficient studies for yiela nd yield attributing character in cow pea (*Vigna unguiculata* L,). *Recent Hort.* 1(1): 61-67.

Mishra, M.1981. Interrelationship between yield and its components in fodder rice bean. *Environ. Ecol.* 13(2):430-432.

Mukherjee, A. K., Roquib, M. A., and Chatterjee, B. N. 1980. Rice bean K-1 for scarcity period. *Indian Farming.* 29 (12): 19-20.

Murthy, B.R. and Arunachalam, V. 1966. The nature of divergence in relation to breeding system in some crop plants. *Indian J. Genet.* 26:188-198.

Nagalakshmi, R.M., Kumar, R.U. and Boranayak, M.B. 2010. Assessment of genetic diversity in cowpea. (*Vigna unguiculata*). *Electr. J. Plant Sci.* 1: 453-461.

Nath, A. and Tajane, P. A. 2014. Genetic variability and diversity for green forage yield in cow pea [*Vigna unguuiculata* L. Walp]. *Int. J. Plant Sci.* 9(1): 27-30.

Navaselvakkumaran, T., Babu, C., Sudhagar, R., and Sivakumar, S.D. 2019. Studies on interrelationship and path coefficient analysis of fodder yield and yield component traits in fodder cowpea (*Vigna unguiculata* L. Walp). *Electr. J. Plant Breed*. 10 (2): 720-726.

NDDB [National Diary Development Board]. 2016. *Annual Report* 2015-2016.National Diary Development Board, Anand, 135p.

Neelam, S., Kumar, V., Natarajan, S., Venkateshwaran, K. and Pandravada, S. R. 2014. Evaluation and diversity observed in horsegram (*Macrotyloma uniflorum* (Lam.) Verdc.) germplasm from Andra Pradesh. *Int. J. Plant Res.* 4(1):17-22.

Pandey, G., Prasad R., Prasad, B., and Chauhan, P. 2015. Co-efficient of variation, heritability, genetic advance and variability for ricebean (*Vigna umbellata*

(Thunb.) genotypes under mid hill conditions of Uttarakhand. *J. Appl. Nat. Sci.* 7 (2): 794 – 798.

Panse, V. G. and Sukhatme, P. V. 1985. Statistical methods for Agricultural workers. ICAR, New Delhi, 246p.

Pol, K. M., Aawari, V. R., Ugale, S. D., and Thakur, D. R. 2001. Periodical correlation of various marpho physiological and yield contributing characters with grain yield in rice bean (*Vigna umbellata* (L.). *Ann. Plant.* 15(20): 159-162.

Ponmariammal, T. and Das, V.L.D. 1996. Correlation and path analysis for fodder yield in cow pea. *Madras Agric. J.* 83:660-661.

Prakash, B. G., Channayya, P., Hiremath, S. B., Devarnavdgi and Salimath, P. M. 2010. Assessment of genetic diversity among germplasm lines of horse gram (*Macrotyloma uniflorum*) at Bijapur. *J. Plant Breed.* 1(4):414-419.

Prashanthi, L. 2004. Variability and heritability studies in cow pea. *J. Maharastra Agric. Uni.* 29(3): 362-363.

Praveena, V. S., Abraham, M., and Kumar, V. 2019. Genetic divergence studies in fodder cowpea (*Vigna unguiculata*) using D^2 statistics. *Forage Res.* 44(4): 230-236.

Radhakrishnan L., Murugan, M., and Sivakumar, T. 2007. Biomass yield, chemical composition and nutritive value of *Desmanthus virgatus* (hedge lucern) for sheep. *Animal Nutr. Feed Technol.* 7:119-123.

Rao, C. R. 1952. Advanced Statistical methods in Biometrical Research. *Agric. Sci. Digest.* 20(1): 66-67.

Rony, B. U., Islam. A. K. M., Rasul, G., and Zakaria, M. 2019. Genetic Analysis of Yield and Related Characters of Lablab Bean. *J. Nepal Agric. Res. Council* (5): 1-21.

Roquib, M. A. and Patnik, R. K. 1990. Genetic variability in forage yield and its components in cowpea. *Environ. Ecol.* 8(1): 236-238.

Roquin, M.A. and Das, M. 1995. Genetic divergence in rice bean (*Vigna umbellata*). *Advances in Plant Sci.* 8(2): 312-318.

Rudragouda and Angadi, S. S. 2002. Impact of spacing and fertility levels of yield and quality of rice bean (*Vigna umbellata*) genotypes for forage production. *Karnataka J. Agric. Sci.* 15(4):685-687.

Sahu, P.K., Mishra, T.K., Singh, G.S., Mishra, C.H.P. and Mishra, R.C. 2007. Genetic diversity, character association and path coefficient study in rice bean. *Environ. Ecol.* 25(3): 808-812.

Santhosha, G.R., Shashikanth, E., Gasti, V. D., Prabhuling, G. V., Rathod, D. and Mulge, R. 2016. Genetic variability studies in cluster bean [*Cyamopsis tetragonaloba* (L.) Taub.] for growth, yield and quality parameters. *Legume Res*. (40):232-236.

Santhoshkumar, S., Tyagi, I.D. and Kumar, S., and Singh, B. 2002. Analysis of fodder yield components in segregating generation of cow pea [*Vigna unguiculata* (L.) Walp]. *Prog. Agric*. 2(1): 22-25.

Sarkar, A. and Bhattaharya, S. 2007. Metroglyph and index score analysis in germplasm of rice bean [*Vigna umbellata* (Thunb.). ohwi ohashi]. *Forage Res*. 33(1): 44-47.

Sarkar. A. and Mukherjee, S. 2007. Studies on genetic variability in rice bean germplasms under terai region of West Bengal. In: National Symposium on “A new vista to forage crop research. Kalyani:10-11 Septmber 2007, BCKV, West Bengal,34p.

Sarma, B.K., Singh, M. and Pattanayak, A. 1991. Evolution of rice bean (*Vigna umbellata*) germplasm in upland trraces of Meghalaya. *Indian J. Agric. Sci.* 61(3): 182-184.

Sastrapradja, S. and Sutarno, H. 1977. *Vigna umbellata* in Indonesia. *Ann. Bugor*. 6: 155-167.

Seehalak, W., Tamooka, N., Waranyuwat, A., Thipyapong, P., Laosuwan, P., Kaga, A. and Vaughan, D.A. 2006. Genetic diversity of *vigna* germplasm from Thailand and neighbouring regions revealed by AFLP analysis. *Genet*. *Resour*. *Crop Evol.* 53(5): 1043-1059.

Sen, R., Sain, R. K., Singh, S. K., and Kumar, A. 2019. Study of genetic variability of fodder yield and its components in forage sorghum (*Sorghum bicolour* (L.). *Forage Res.* 2: 123-126.

Seyie, K., Handique, G. K., and Handique, A. K. 2006. Evaluation of indigenous land races of rice bean (*vigna umbellata*) from Nagaland for growth and yield attributing characters. *Indian J. Plant Genet. Resour.* 19(2): 209-214.

Sharma, M., Sharma, P. P. Sharma, H., and Meghawal, D. R. 2017. Genetic variability in cowpea [*Vigna unguiculata* (L.) Walp.] Germplasm lines. *J. Pharmacol. Phytochemistry* 6(4): 1384-1387.

Singh, D. and Chauhan, A. 2017. Fodder yield, quality and nutrient uptake potential of different types of sorghum (*Sorghum bicolor*) varieties in central Gujarath. *Forage Res*. 43(2):121-128.

Singh, K. N.,Chauhan, D. S.and Tomar, V. P. S. 1979. Performance of different varieties of fodder cowpea in semi-arid Regions of Rajasthan. *Forage Res*. 5(1): 85-88.

Singh, M.R.K., Chakravarti, D and Singh, N.B. 1997. Genetic variability, correlation and path analysis in rice bean (*Vigna umbellata* (Thunb.) Ohwi and Ohashi) cultivars of Manipur. . *Indian J. Hill Farming 1*0(1/2): 23-28.

Singh, M.R.K., Sharma, P.R. and Singh, L.I. 1999. Genetic divergence among rice bean (*Vigna umbellata* (Thumb.) Owhi and Ohashi) cultivars in Manipur. *Indian J. Genet. Plant Breed.* 59(2): 221-225.

Sivasubramanian, S. and Menon, M. 1973. Heterosis and Inbreeding depression in rice, *Madras Agric*. J., 60:13-39.

Sonene, A.H., Jadhav,S.J., Dahat, D.V. and Aher, R.P. 1999. Path analysis in rice bean (*Vigna umbellata*).*Legume Res*. 22: 195-197.

Tamooka, N., Kaga, A., Isenura, T., and Vaughan, D. 2011. *Vigna*: chapter 5. In Chittaranjan, K. (Ed). Wild crop relatives: Genomic and Breeding resources, legume crop and forages.449p.

Thakur, G. S. 1990. Genetics of fodder yield and its components, genetic divergence and stability in soya bean [*Glycine max* (L.) Merrill] under different environments. PhD (Ag) thesis, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur 332p.

Thaware, B. L. Toro, V. A., and Birari, S. P. 1992. Genetic parameters and correlation studies in forage yield components of cowpea. *J. Maharastra Agric. Univ*. 12(2): 65-68.

Thorat, A. and Gadewar, R. D. 2013. Variability and correlation studies in cowpea [*Vigna unguiculata* (L.) Walp.]. *Int. J. Environ. Rehabil. Conserv.* 4(1):44-49.

Trehan, K.B., Bagrecha, L.R. and Srivatsav, U.K. 1970. Genetic variability and correlation in cowpea (*Vigna radiata* L.) under rain fed conditions. *Indian J. Heredity* 2(1): 39-43.

Tyagi, P.C., Kumar, N. and Agarwal, M.C. 2000. Genetic variability and association of component characters for seed yield in cowpea (*Vigna unguiculata* (L.) Walp): *Legume Res*. 23(2): 92-96.

Watson, D.J. 1952. The physiological basis of variation in yield. *Ann. Bot.*6:101-105.

Wright, S. 1921.Correlation and causation. *J. Agric. Res.* 20: 257-287.

Yadav, M E., Jagadeeswary, V., Satyanarayan, K., Kiran, M. and Mohankumar, S. 2017.Fodder Resource Management in India- A Critical Analysis. *Int. J. Livest. Res.*7(7):14-22.

Yogeesh, L.N., Viswanatha, K.P., Madhusudhan, R., and Gangaprasad, S. 2016. morphological diversity and genetic variability in moth bean. *Int. J. Sci. Environ. Technol*. 4 (5): 1912 – 1924.

Zeinab, M., Naby, A. E., Rajab, M. N., and Ahmed, I. M. 2015. Evaluation of some promising berseem clover populations for yield, quality, genetic variability and path-coefficient analysis. *Egypt J. Breed.* 19(1): 2015.

GENETIC ANALYSIS IN FODDER RICE BEAN (*Vigna umbellata* (Thunb.) FOR YIELD AND QUALITY

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ABSTRACT

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Rice bean is an underutilized fodder legume, belonging to family Fabaceae, having chromosome number 2n=22. It is emerging as a potential nutritious high yielding animal fodder with no major pest and disease incidence and demands no fertilizer and little special care during growth. In India and Nepal it is mainly grown in two seasons February and March for harvest during summer and in July and August for harvest during December. It can be grown as sole crop or inter crop with maize and sorghum.

The present investigation 'Genetic analysis in fodder rice bean (*Vigna umbellata* (Thunb.) for yield and quality' was conducted at Department of Plant Breeding and Genetics, College of Agriculture, Vellayani. 30 genotypes of rice bean collected from NBPGR were evaluated in Randomized Block Design with three replications. The crop was harvested at 50% flowering stage. Observations were recorded for various qualitative and quantitative characters, viz. days to first flowering, days to 50% flowering, plant height, number of branches, number of leaves, leaf fresh weight, stem fresh weight, green fodder yield, leaf dry weight, stem dry weight, dry fodder yield, leaf area index, leaf stem ratio, production efficiency, crude protein, crude fiber and dry matter production. Various statistical tools such as analysis of variance, genotypic coefficient of variation (PCV), phenotypic coefficient of variation (GCV), heritability, genetic advance, correlation studies, path analysis and cluster analysis were carried out to find out extent of variation present in existing genotypes. Analysis of variance was found to be significant for all the characters except for the character days to 50% flowering. This reveals the presence of variability among the genotypes and hence selection can be effective in the population.

The genotype IC341991 recorded maximum leaf fresh weight (17.41 t ha^{-1}), stem fresh weight (21.87 t ha^{-1}), green fodder yield (35.49 t ha^{-1}), leaf dry weight (2.5 t ha^{-1}), stem dry weight (3.82 t ha^{-1}) and dry fodder yield (6.46 t ha^{-1}), which was on par with the genotypes IC341986 and IC521350. Minimum green fodder yield was recorded by the genotypes EC98452 (22.32 t ha$^{-1)}$ IC341998 (23.25 t ha^{-1}) EC16136 (24.12 t ha^{-1}). Maximum Crude protein content was recorded for the genotypes IC521119 (21.0%), IC521152 (20.27%) and IC521115 (19.74%) while minimum

crude protein content was reported for the genotype IC18553 (13.30%). Crude fibre content was found to be high for the genotype IC469192 (6.7%) and lowest crude fibre content was recorded for the genotype EC98452 (2.8%).

The parameters of genetic variability such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV). Heritability (H^2) and Genetic Advance (GA) were carried out to find genetic variability present in the genotypes. All PCV values were highest then the GCV values, indicating least influence of environment on the expression of characters. Maximum PCV and GCV were observed for the characters crude fibre and dry fodder yield. High heritability coupled with high genetic advance was reported for the characters dry matter production, crude fibre, leaf area index, crude protein and dry fodder yield. High heritability and genetic advance indicates presence of additive gene action and hence selection of these characters will be rewarding.

Correlation studies gives information about degree and magnitude of relationship between two or more variables. Green fodder yield showed significant positive correlation with number of leaves, stem fresh weight, production efficiency, stem dry weight, leaf area index, dry fodder yield, leaf fresh weight, dry matter production, number of branches, plant height, leaf dry weight, crude fibre and leaf stem ratio. Path analysis is a multiple regression statistical analysis which partitions the correlation coefficients into measures of direct and indirect effect. path analysis revealed that characters production efficiency, leaf dry weight, plant height, number of leaves, crude protein, leaf fresh weight, leaf stem ratio and number branches showed direct positive effect on green fodder yield.

Cluster analysis was carried out to know the extent of genetic diversity present in the population. Based on D^2 statistics 30 genotypes of rice bean were grouped into 5 clusters following Tocher's method. Cluster I being the largest cluster contains 12 genotypes followed by cluster III (10 genotypes), cluster IV (4 genotypes), cluster III (3 genotypes) and cluster V (1 genotype). Highest intra cluster distance was observed in the genotypes falling under the cluster III followed by IV and II. Maximum inter cluster distance was observed in the genotypes falling under the cluster III and V, followed by II and III and I and V. Genotypes should be selected from the clusters which shows highest divergence for the success of breeding program.

The study revealed presence of ample amount of variability among the genotypes for all the characters studied. The genotype IC341991was found to be superior in terms of yield and yield attributing characters followed by genotypes IC341986, IC521350 and IC521134. These superior genotypes can be forwarded for further trials for variety development or can be used as parents for future breeding work.