Screening of Ricebean Germplasm Lines for their Growth Quality and Nitrogen Fixing Efficiency

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

In partial fulfillment of the requirement
For the Degree of

MASTER OF SCIENCE

In

AGRICULTURE
(SOIL SCIENCE AND AGRICULTURAL CHEMISTRY)

By

SWATI TIWARI

Department of Soil Science and Agricultural Chemistry
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
College of Agriculture
Jabalpur (M.P.)

2012

CERTIFICATE - I

This is to certify that the thesis entitled **“**Screening of ricebean germplasm lines for their growth quality and nitrogen fixing efficiency” submitted in partial fulfillment of the requirement for the degree of **“MASTER OF SCIENCE” in Agriculture (Soil Science and Agricultural Chemistry)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Swati Tiwari** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instruction.

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

Place : Jabalpur
Date : ....

(Dr. B. Sacchidanand)
Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE

Chairman	**Dr. B. Sacchidanand**	....
Member	**Dr. A.K. Rawat**	....
Member	**Dr. R.B. Singh**	…………………………………….
Member	**Dr.(Smt.) Seema Paroha**	....

CERTIFICATE – II

This is to certify that the thesis entitled **" Screening of ricebean germplasm lines, for their growth, quality and nitrogen fixing efficiency"** submitted by Swati Tiwari to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfillment of the requirements for the degree of **"Master of Science in Agriculture"** in the Department of **Soil Science and Agricultural Chemistry** has been approved after evaluation by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

Place: Jabalpur

Date: …………..

(Dr. B.Sacchidanand)

Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	**Dr. B. Sacchidanand**	…………………
MEMBER	**Dr. A.K. Rawat**	…………………
Member	**Dr. R.B. Singh**	…………………
Member	**Dr.(Smt.) Seema Paroha**	…………………
Head of Department	**Dr. A. K. Rawat**	....
Director of Instruction	**Dr. P.K Mishra**	…………………

ACKNOWLEDGEMENT

I bow my head with great reverence before God, whose ideologies have always been an inspiring source in my life and has enabled me to achieve this seemingly invincible task.

Space does not allow to my desired extent and words fail to express my immense esteemed gratitude to chairman of my advisory committee Dr. B. Sacchidanand, Principal scientist Department Soil science and Agricultural chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur for his splendid credentials in strengthening my potentials, insightful and inspiring guidance does supervision and constructive criticism and counsel, during the course of my investigation and study which had made it possible to accomplish this stupendous task.

I am deeply obliged to all the venerable members of the advisory committee viz., Dr. A.K. Rawat Principal Scientist, Department of soil science and Agricultural Chemistry ,JNKVV , Jabalpur, Dr. (smt.) Seema Paroha, Senior Scientist, Department of Plant Physiology and Dr. R. B. Singh, Associate Professor, Department of Mathematics and Agricultural Statistics for their valuable suggestions and help during the course of study.

I would like to place on record my gratitude Dr. A.K. Mehta, Principal scientist, Department of Plant Breeding and Genetics , Dr. A.K. Upadhyay Assistant professor Department Soil science and Agricultural chemistry, JNKVV, Jabalpur for his valuable guidance and fruitful suggestions during the course of study and preparation of manuscript.

I feel myself duty bound to express my deep sense of gratitude and thanks to Dr. N. N. Pathak Hon'ble Vice Chancellor, Dr. S.S. Tomar, Director Research Services, Dr. P.K. Mishra, Director of Instructions and Dr. D.K. Mishra, Dean, College of Agriculture, JNKVV, Jabalpur for providing facilities to conduct this research work.

I am deeply indebted to express my heartfelt and sincere thanks to my teachers, Dr. P.S. Kulhare, Dr. S.D. Sawarkar, Shri G.P. Tembe, , Shri S.S. Baghel, Dr. G.D. Sharma, Dr. R.K. Thakur, Mr. R.K. Sahu and my respected seniors Mr. Komal , Mr. P.C. Amule, (Smt.) Sangeeta Thakur; Mr. Pankaj Dillewar ,Mr. Narendra Chouhan , Mr. Rajneesh Singh Sapna madam, Rachna madam, Rajkumar, STCR staff Shri Gammulal , Bhikam , Subhash and other staff members of Department of Soil Science and Agricultral Chemistry, for their helping attitude during the experiment and course work accordingly.

I wish to express, my unbounded love and respect toward my father Shri Rishiswar Tiwari, mother Smt. Jyoti Tiwari ,my Father-in-low shri R.S. Agnihotri ,Mother-in-low Smt. Sarla Agnihotri loving sister Akanksha and elder brother Sulabh Tiwari, and my loving nephew and nieces Anant ,Amrita , Om , Aishwarya , Jhalak ,Aarya and also thank to my adorable husband Mr. Anand Agnihotri for molding my life with a smile of love and affection, which has made me a complete human being.

I appreciate the constant, assistance, affection and appreciation rendered by my juniors and friends namely, Vaishali , Pratibha , Spriha ,Sweety and Anvita for encouraging my self confidence.

Last work but least I would give special thanks to a Yadav Computer's for preparing this manuscripts.

Date : **(Swati Tiwari)**
Place :

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LIST OF ABBREVIATION

et al.	-	And others
%	-	Percentage
^{0}C	-	Degree centigrade
SEm	-	Standard error of means
C.D.	-	Critical difference
µ	-	Micron
cv.	-	Cultivar
>	-	More than
No.	-	Number
ppm	-	Parts per million
g	-	Gram(s)
ha	-	Hectare(s)
Agril.	-	Agricultural
ha	-	Hectare
kg	-	Kilogram(s)
mg	-	Milligram
ml	-	Milliliter
Vol.	-	Volume
Fig.	-	Figure
E.I.	-	Effective index
±	-	Plus or Minus
ODW	-	Oven Dry Weight
i.e.	-	That is
viz.	-	Namely
cfu	-	Colony forming unit
DAS	-	Days after sowing
cm	-	Centimeter

INTRODUCTION

Ricebean (*Vigna umbellate*) ohwi and ohashi previously known as (*Phaseolus calcaratus)* is a warm season annual vine legume with yellows flowers and small edible beans. It is commonly called ricebean, is regard as a minor food and fodder crop and is often grown as intercrop or mixed crop with maize, sorghum, cowpea as well as sole crop in the uplands on a very limited area.

Artificial crosses have been made between *V. mungo* and *V. umbellata* to produce improved mung bean varieties. The cultivated Asiatic *vigna* species belong to the sub genus *ceratotropis*,a fairy distinct and homogeneous group, largely restricted to Asia, which has a chromosome number of 2n=22 (exept *V.glabrescem ,2n=44).There* are seven cultivated species in the subgenus, including *mung bean* (*V. mungo*), adzuki bean (*V.angularis*) and mothbean (*V. aconitifolia*) as well number of wild species (Singh *et al.* 2006).

The presumed centre of domestication of Rice bean is Indo-China. The distribution of this crop from southern china through the north of Vietnam, Laos, Thailand, Burma, India and Nepal comes under area of cultivation (Khadka and Acharya 2009). It is cultivated to limited extant in India, Burma, Malaysia, China, Fiji, Mauritius and Philippines (Fery 1980). The Rice bean as an orphan crop has received only little scientific attention, thus there are no improved varieties and it has fallen behind the major pulses in India and Nepal.

The observed area which farmer use for Rice bean varies between 20 and 1500 meter square in Nepal and 1.5 to 1000 meter square in India . Nepalese farmer harvest calculated 0.1 to 0.6 kg per meter square. Indian farmer harvest 0.1 to 1.0 kg per meter square (Buergelt and Oppen 2009).

It has wide adaptability to varying nature of soil as well as climatic condition Rachie and Roberts (1974) classed rice bean as adapted to sub humid regions with 1000-1500 mm precipitation. It performs well under acidic soils condition and tolerant to high level of phytotoxic elements like AI, Fe and Mn (Dwivedi *et al.* 1994 and 1996).

The beans are frequently cooked with rice hence named rice beans. There are many varieties of rice bean. The seed color ranges from ivory to greenish ivory, red, violet, and black (Chatterjee and Dana 1997).

The world vegetable centre based in Taiwan has 197 accession of rice bean including 8 genotypes from Nepal and 24 from India (World Vegetable Centre 2007). As well as the collection held at the Indian institute for pulse research and the NBPGR Station at Bhowali, U.P. also maintains collection over 300 genotypes. (Negi *et al.*1996).

The rice bean has always been used as an established pulse in India and Nepal because of its nutritious value. All varieties seem to be good source of protein, essential amino acid, essential fatty acid and minerals (Mohan and Janardhanan 1994). Nutritionally dry seeds of rice bean are good source of carbohydrates (58.2% - 72%) and crude protein (18.3% - 32.2%) as well as rich in limiting amino acid metheonine and tryptophan (Carvalho and Vieitra,1996). It also has good contain of ash (3.5% - 4.9%) and crude fibre (3.6 – 5.5%), (Buergelt *et. al.* 2009).

It is practically soil improving, nitrogen fixing manure crop and valuable legume for erosion controlling on steep slopes and banks. In Asia the bean is planted in rice field after rice is harvested to add nitrogen and humus to benefit succeeding crops. It has nodule that has bacteria, which is capable to fix elemental nitrogen symbiotically, plays a key role in maintaining soil fertility. It has been reported that it saves 25 to 40% of nitrogen to reduce quantity of recommended dose of nitrogen for wheat crop (Annoymous 1991).

Rice bean grows well in various soil types and shows pest resistance and also has potential for good fields of nutritious fodder and high quality grains .The uses of rice bean is mainly for human dietary uptake with a smaller portion used for fodder and green manure (Joshi *et al.* 2006). It is valuable as high class fodder which is known to increase milk production in livestock, whole plants are used as forage for livestock, especially for pigs. However, further investigation has to be conducted to screen out the best and efficient germplasms which can be highly nutritious as fodder for livestock and also helpful in maintaining soil fertility through nitrogen fixation.

Therefore present investigation entitled **"Screening of ricebean germplasm lines for their growth, quality and nitrogen fixing efficiency"** was undertaken with the following objectives:-

- To screen out different germplasm lines of rice bean bearing high nodulation.
- To study and evaluate nitrogen fixing efficiency by germplasm line of rice bean
- To find out the effect of germplasm lines on chemical properties of soil and nutrient uptake by rice bean crop best suited for fodder.

REVIEW OF LITERATURE

Nature has tremendous capability to balance its creatures. Biological diversity is one of them due to which nature made it possible to govern the ecology. An attempt has been made to bring out review relating to objectives of the investigation studied by other scientists and researcher in India and abroad has been documented in this chapter.

2.1 Effect of ricebean germplasms on soil properties.

2.1.1 Nitrogen

Dubey and Shrivastava (1991) conducted field trials during the kharif and rabi seasons of 1988 – 89 on vertisols, with a basal dose of 20:60:40 and 30:33:60 kg NPK ha^{-1} respectively to soybean. Cultivation of soybean significantly improved the available N status of soil by 164.79 kg/ha in the un- inoculated and 215.20 N kg ha^{-1} in the inoculated plot as against initial status of 155.34 kg ha^{-1}.

Kurdali (1996) found that at physiological maturity, chickpea had accumulated 103 kg N ha^{-1}, 60% of which was derived from fixation 35% from soil and 5% from fertilizer.

Shahandeh *et.al*. (2004) documented the seasonal dynamic of soil inorganic N after sorghum (*sorghum bicolor*), millet (*Pennisetum glaucum*), and cowpea (*Vigna unguiculata*) crop rotation. A sharp increase in soil N was observed early in the rainy season. Extractable N concentration peaked between 15-22 kg and 33-51kg N ha^{-1} in the upper 10cm of soil.

Sultani *et.al* (2004) conducted a two year study to investigate soil nutrient dynamics influenced by various legumes (sesbania, cluster bean, rice bean) at different P levels (0, 30, 60, 90 kg P_2O_5 ha^{-1}) effect of incorporation green manure crops and P levels on

NPK content of soil differed among various treatments. Sesbania caused an increases of about 26, 18 and 37% N,P and K respectively , followed by clusterbean i.e 21 ,22 and 29% in soil respectively over control. The percent increase in soil N,P,K by rice bean over control was the lowest i.e. 16,11,23% respectively .The influence of P levels on soil was also considered and was to be maximum with 90 kg ha^{-1} on an average ,the overall effect of P application on N,P,K status of soil increase by 5,6 and 3% respectively over control.

Emmanuel and Francis (2010) carried out an experiment to investigate the use of long yam bean as soil amendment .The results revealed that there were significant increases in the soil pH O.M., N, P, K and Mg as compared to control treatment. Over all the long yam bean increased the soil pH ,O.M., N, P, K Ca and Mg by 7.2 (29%), 2.70 (92%), 1.37 (97%), 27.30 (86%), 1.40 (96%), 0.91 (97%) and 0.65 (89%) compared to control treatment having value 5.1, 0.21, 0.04, 3.40, 0.05, 0.03 and 0.07 respectively.

2.1.2 Available Phosphorus

Sharma (1992) also reported that the highest build up in soil available phosphorus was 66.2 kg ha^{-1} and 54.6 kg ha^{-1} in surface and sub surface soil layers respectively with the application of FYM and crop residue treated plots as compare to control plot. It was attributing to their beneficial effect on soil physiochemical and microbiological properties.

According to Qasim *et.al*.(1994) the legumes increased soil organic matter, decreased available P, increased infiltration rate and decreased soil pH. Soil available K was decreased by soybean, pigeonpea and ricebean, and slightly increased by mung bean and mash bean.

Reddy and Surekha (1999) reported that the buildup of available phosphorus 17.0-19.0 kg ha^{-1} (0-25 cm) and 21.0-22.8 kg ha^{-1} at (25-50cm) depth received application of 40 kg P ha^{-1} as compared to fallow plot in which the available P-recorded only 9.5 (0-25cm) and 5.9 (25-50cm) ha^{-1} in vertisol with chickpea upland rice system chickpea has ability to access. P normally not available to other crop in a vertisol by mobilizing sparingly soluble Ca-P by acidification of rhizosphere through its citric acid exudates.

2.1.3 Available Potassium

Prasad *et.al*. (1982) noted a marked improvement in available K content in long term fertilizer experiment from the initial level (190 kg ha^{-1}) to a maximum of 368 kg ha^{-1} in 150 % NPK treatment the larger accumulation of available K was reported to be 392 kg ha^{-1} in treatment where K was applied with FYM.

Senger *et al.* (1990) reported that the available K *w*as maximum in surface layers (492.8 kg ha^{-1}) and decreased fast with increasing soil depths only up to 50cm and then got stabilized or again registered in increase with depth by the application of (100% NKP + FYM) and 100% N only.

Dubey and Shrivastava (1991) reported that the K level declined to 193.58 and 300.75 kg ha^{-1} in the un-inoculated and inoculated plots respectively as compared to the initial status of 635.69 kg ha^{-1} .

2.1.4 Soil pH

Gaikwad and Khupse (1976) reported no noticeable change in soil pH due to continuous use of fertilizer and biofertilizer.

Choudhry *et.al*. (1981) conducted a long term experiment at Hissar for 9 years and found that pH of the soil remained more or less unaffected under various fertility level.

According to Tang *et.al.* (1997) nitrogen fixing plants take up more cations than anions thus net efflux of H^+ into the rhizosphere occurs resulting in decrease in rhizosphere pH.

Kamh. *et.al*. (1999) reported that white lupine (*lupinus albus*) exuded organic acid anions and protons that lowered rhizosphere pH and recovered considerable amount of P from soil and made them more available to wheat then when it is grown in monoculture

According to Li *et. al.* (2004) legumes such as alfa-alfa, chickpea, lupines and cowpea can release considerable amount of organic anions and lower their rhizosphere pH.

2.1.5 Organic carbon.

Bhogal *et.al* (1993) found that available Zn, Cu Fe, Mn and B were significantly and negatively correlated with pH and positively with organic carbon.

Mitchelli and Entry (1998) studied the SOC and N cycling in long term planting of winter legumes and found that no other source of N applied resulted in higher SOC (9.5g C kg^{-1}) in the plow layer (0-20 cm depth) compared to continuous cotton with no winter cover crops (4.2g C kg^{-1}). A 3 yr. Rotation of cotton winter legumes – corn – small grain soybean resulted in 12.1g C kg^{-1}. winter legume cover crops supplied between 90 and 170 kg N ha^{-1} where no N has been applied in fertilizer or from a legume crop, annual removal in cotton crop is around 13 kg $ha^{-1.}$

Dwivedi *et al.,* (2008) reported that the data obtained in soybean – wheat cropping system under LTFE resulted in improvement of organic carbon content from 0.57 to 0.99% in vertisols of Jabalpur.

2.1.6 Sulphur

Setia and Sharma (2005) have reported that the increasing levels of N, P and K affected depth wise distribution of S. The S content increased with application of 40 kg P_2O_5 ha^{-1}. The accumulation of sulphur was lower in the NPK treated plots than N and NP treated plots. The distribution pattern of sulphur revealed that all the S form decreased with increasing depth.

2.2 EFFECT OF RICEBEAN GERMPLASMS ON MICROBIAL POPULATION

According to Odunfa and Oso (1978), the number of active fungal propagates in the rhizosphere was highest at the seedling stage and decreased until about 50 days, after which a gradual rise was observed culminating in another peak at about 100 days.

Pankhurst *et al*., (1995) also reported that microbial population or activity can precede detectable changes in the soil's physical and chemical properties there by providing an early sign of soil's improvement or an early warning of soil degradation

Patil and Varade (1998) studied the effect of application of NPK fertilizers to a sorghum-wheat cropping sequence on a vertisols in a field experiment and reported that population of bacteria, fungi and actinomycetes were affected significantly with different rates of fertilizer treatments at all the crop growth stages. Fungi,bacteria and actinomycetes proliferated under NPK and FYM, increasing microbial population were noticed after 30 DAS and declined at the harvesting stage.Bacteria and actinomycetes showed significant and positive correlation with yield, nutrient uptake and available nutrient status under organic and inorganic treatments while fungi showed positive effect under inorganic treatments and negative effect under FYM.

Venkateswarlu and Shrinivasrao (2004) studied diversion of microbial population in soil in relation to various agricultural practices. In the soil profile the microbial population majorly occur in 40 cm of top soil, bacteria are predominant followed by actinomycetes and fungi management .practices such as irrigation, tillage, cropping fertilizer application. Residue incorporation manure and microbial inoculation have major impact on diversity of biological population in soil. Diversity index was much higher in alfisols than vertisol. Under different crop management practices

Song *et.al.* (2007) investigated crop yield and various chemical and microbiological properties in rhizosphere of wheat, maize and faba bean grown in the field solely and intercropped (wheat /faba bean, wheat/maize and maize/faba bean) in the second third year after establishment of the cropping systems. In both years intercropping increased crop yield. Changed N and P availability and affect the microbiological properties in rhizosphere of three species compared to sole cropping. In the third year of different cropping systems, intercropping significantly changed and the effect were most pronounced in the wheat faba bean intercropping system.

According to Mahajan *et. al.* (2007), the bacterial fungal and azotobacter population were maximum in plots treated with 100% NPK + FYM while actinomycetes population was maximum in 100% NPK+Lime. The bacterial population decreased and fungal population increased with increasing NPK i.e. from 50% to 150% NPK.

Patkowaska (2008) reported the laboratory microbiological analysis of the rhizosphere soil of common bean which showed that the population of bacteria in 1gm of dry soil weight ranged on average from 0.66 x 10^6 to 2.85 x 10^6 cfu. The total population of fungi in the particular studied year ranged from 5.87 x 10^3 and 22.84 x 10^3 cfu g^{-1} respectively.

Dong *et al.* (2008) studied the effect of different nitrogen application rate co. 90, 180 and 270 kg ha^{-1} on the rhizosphere microbial community and its diversity in wheat fababean intercropping system. The amount of rhizosphere microbes were high at the flowering stage with increasing nitrogen application rate the amount of rhizosphere microbes in wheat rhizosphere were increase first and decreased than, with peak appeared at 180 kg N.

Zahir *et al*.(2010) .conducted study to assess the influence of green manure legumes and N fertilizer on soil microbial biomass and activities in rice (*Oryza sativa*) -wheat (*Triticum aestivum*) system. The results showed that the green manure legumes and N fertilizer application significantly increased the microbial biomass and activities in rice-wheat system. The average improvement gained from the green manure legumes relative to (fallow-based-rice-wheat) FRW, was 1.79 times for microbial activities, 1.70 times for microbial biomass-C (MBC), 1.49 times for microbial biomass-N (MBN), 1.82 times for C mineralization, 1.92 times for N mineralization, 3.36 times for bacterial population and 1.46 times for fungal population. The average improvement gained from N fertilizer (+N) relative to no N fertilizer (0N), was 1.40 times for microbial activities, 1.17 times for MBC, 1.29 times for MBN,1.42 times for C mineralization, 1.45 times for N mineralization, 1.17 times for bacterial population and 1.42 times for fungal population. Their results suggest that the microbiological attributes proved to be highly responsive and sensitive to the beneficial influence of green manure legumes in rice-wheat system and can be used as indicator of soil quality.

2.3 EFFECT OF GERMPLASM ON NUTRIENT UPTAKE

2.3.1 Phosphorus-

Bharadwaj *et.al*. (1984) in a long term experiment found that the uptake of N, P, K, Fe, Mn. and Cu generally increased with the increase in crop yield.

Kanakeri, (1991) conducted field experiment at main Agricultural Research Station, Dharwad, Karnataka, uptake of nitrogen, phosphorus, potassium by maize was found reduced significantly due to intercropping (263,13 and 138 NPK kg ha^{-1}) as against sole cropping (305, 16 and 188 NPK kg ha^{-1}). Uptake of nitrogen with greengram (284 kg ha^{-1}) was significantly higher than with cowpea (239 kg ha^{-1}) and soybean (247 kg ha^{-1}) as intercrops, the nitrogen uptake was maximum in 1:1 row ratio (274 kg ha^{-1}) compared to 1:2 row ratio (251 kg ha^{-1}). Further, among different intercrops, cowpea recorded maximum uptake of nitrogen (68 kg ha^{-1}), phosphorus (2 kg ha^{-1}) and potassium (18 kg ha^{-1}) followed by soybean with 60, 2 and 18 kg ha^{-1} N P K respectively.

Fageria *et al*. (1995) conducted four greenhouse experiments in an oxisol to evaluate response of liming (0.2 and 4 g kg^{-1}) and P application (0.50 and 175 mg P kg^{-1}) on growth and nutrient uptake by rice, wheat, common bean and corn. In all crops increasing levels of applied P significantly increase nutrient uptake. Decrease in potassium (K) uptake, due to high lime, is probably due to antagonistic effect of Ca and Mg and reduced micronutrient uptake is probably due to increase soil pH resulting in decreased availability of these elements to plants.

According to Dutta *et al*. (1996) Nitrogen and phosphorus uptake increased with increasing concentrations of phosphate, with the highest rate recorded following the application of 40 kg P_2O_5 ha^{-1} in ricebean and cowpea.

A field trial conducted by Mohapatra (1996) at Semiliguda, Orissa, V. umbellata cv. SRBS-43 was given 0-40 kg N and 20, 40 or 60 kg P_2O_5 ha^{-1}. Number of pods/plant, 1000-seed weight, P uptake and seed yield increased with rate of N and P application.

Mahriya and Meena (1999) recorded corresponding increasing in plant high number of branches plant dry matter production/m^2 and protein content of cowpea cv. Rc-19 with increasing rate of phosphorus. The rate of increase was appreciable up to 30 kg P_2O_5/ha only. They also observed considerable increase in N-uptake up to the level of 30 kg P_2O_5 ha^{-1}.

2.3.2 Potassium (K)

Prasad *et.al.* (1982) found the highest K content (1.7%) in when N,P,K fertilizers were applied with FYM, they found that removal of K increased with higher doses of N,P,K. the uptake was only 70.2 kg ha^{-1} as compared to 60.0 kg ha^{-1} in 50% N,P,K treatment.

Prasad and Bhol (1994) conducted a field trial in the kharif season Bhubaneswar, Orissa, *V. umbellata* cv. RBL-6 was sown at 30 x 10, 45 x 10 and 60 x 10 cm spacings and given 0-60 kg N ha^{-1}.The results revealed that Uptake of N, P, K and Ca in grain increased with up to 40 kg N ha^{-1} and were highest with 30 x 10 cm spacing.

Sarkar *et al* (1998) conducted pot experiment, *V. umbellata* was grown at two N levels (0 and 20 kg ha^{-1}), two potassium levels (0 and 40 kg K_2O ha^{-1}), and five soil moisture tensions (0-0.33, 0.33-0.50, 0.33-1.00, 0.33-2.00, and 0.33-4.00 atm.). Dry weight and leaf area were significantly enhanced by N and K application, while moisture stress decreased growth parameters. Application of N and K increased N,P,K uptake. Though moisture stress increased the concentration of N,P,K in plants, the uptake of these nutrients was decreased. Both N and K application increased water use efficiency significantly. Maximum water use efficiency was noted with soil moisture tension at 0.33-1.00 atm. (5.27 g/liter).

2.3.3 Nitrogen

Sarkar and Jones Wyn (1982) revealed that with exception of P,. levels of all other estimated nutrient viz. Na, K Ca, Mg, Fe, Mn, and Zn were significantly differ after 42 days growth as compared to 21 days growth period. The higher uptake in to shoots of Na^{+} ,K^{+}, Fe^{2+} Zn^{2+} and H_2PO_4 and higher biomass accumulation in the rhizosphere were associated with lower rhizosphere pH. The uptake of Ca^{++} and Mg^{2+} increased with higher rhizosphere Ph,when French bean seedlings grown on choline,ammonical and nitrate forms of nitrogen together with equivalent basel application of P as NH_2PO_4 were tested for nutrient from the rhizosphere.

Westermann *et al.* (2011) conducted study to determine the plant and seed uptake of N, P, K, Cu, Mn & Zn by 16 common bean genotypes. Common bean genotypes with higher biomass field in general also had higher nutrient uptake regardless of organic and conventional production system. In general N and P uptakes were high and that for Mn was markedly low among common bean genotypes.

2.3.4 Sulphur

Sharma (1992) revealed the highest soybean yields in recommended N (40 kg ha^{-1}) + 6 t FYM ha^{-1}. There yields were 20.5 and 49.5% more respectively than N was supplied through inorganic fertilizers. N,P,K and S uptake were also highest in the treatments given FYM + half the recommended N rates.

2.4 Effect of germplasms on nodulation and nitrogen fixation in rice bean.

Hardarson *et al*. (1993) investigated the N_2 fixation potential of various cultivars of common bean in different countries i.e. Austria, Brazil, Chile, Colombia, Guatemala, Mexico and Peru, had ranged from 25-165, 412, 10-50, 20-35, 92-125, 0-70, 12-59 in kg ha^{-1} respectively.

Li *et al.*, (1993) stated that the number of effective nodules, the effective nodule dry weight and the nodulation index could be used as parameters to evaluate nodulation and N fixation abilities. They also showed that the relative importance was greatest for effective nodule dry weight and least for nodulation index.

Arya *et al* (1996) conducted a field experiment at Pantnagar, Uttar Pradesh, *V. umbellata* was given 0-60 kg P_2O_5 ha^{-1} as acidulated rock phosphate, Mussooriephos or single superphosphate. Nodulation was highest with single superphosphate and with 60 kg P_2O_5. Dry weight / plant were not affected by P rate or source.

Rochester *et.al.* (1998) reported fababean residues delivering upto 270 kg fixed N ha^{-1} to the field balance, including a contribution as 100 kg ha^{-1} from below-ground legume N residues. Nevertheless, considering that only 160 kg N ha^{-1} was removed with the grains.

Dwivedi (1997) Reported that twenty seven ricebean genotypes of different maturity groups were studied for nodulation behavior at Ranichauri, Tehri Garhwal during kharif 1991 and 1992,of the genotypes studied, only 5 were found to be promising with respect to their rooting systems, nodule numbers, nodule weight, N-uptake, plant height, dry matter and grain yield. Among the promising genotypes, RBL70 and RBL100 were identified as best with respect to deep rooting, nodulation, high yields and tolerance of acid soils. Nodule number, nodule weight and root length were found to be significantly and positively correlated with dry matter, N-uptake and grain yield 45, 60 and 90 days after sowing.

Lindermann and Glover (2003) reported that common beans are poor fixer of nitrogen (less than 50 lbs per acre) which is less than their needs. Other grain legumes such as peanuts cowpeas, soybeans and faba beans may fix up to 2520 lbs of nitrogen acre^{-1}.

Hayat *et.al*. (2008) conducted rotational field experiments on Mung bean, and mash bean during summer of 2002 and 2003 followed by wheat to asses N_2-fixation by bean and their residual effect on subsequent wheat crop. Sorghum was sown as non-leguminous crop with 100 kg N/ha. Nodulation, shoot dry matter, grain yield and N concentration of both beans were increased by phosphorus fertilization. Estimates of nitrogen derived from atmosphere ranged 49.71% during 2nd year and up to 60% increase was observed from 1st year. Average N_2 fixed ranged between 33-55 kg ha^{-1} during both years.

Li *et. al*.(2009) conducted two years field experiments (2006-2007) with different N-fertilizer rates (0.75, 150, 225, 300kg N/ha) to test the hypothesis in a fababean (*Vicia faba l*.) maize intercropping system in north- western part of china. The results show that both the nodule biomass and nitrogen derived from the atmosphere in intercropped faba bean were increased by 7-58% and 8-33% at the start of flowering 8-72% and 54-61% at peak flowering , 4.73% and 18-50% at grain filling and 7-62% and 7-72% at maturity, respectively compared with sole faba bean.

2.5 Plant height

Zaman and Malik (2000) studies to determine a satiable move-ricebean inter cropping were carried out at the agronomic research are university of Agriculture Faisalabad during 1995 and 1996. The experiment was laid out using randomized block design with 4 replications. The treatments were rice bean alone maize + one row of ricebean. Maize + two row of rice bean, maize + three rows of rice bean the plant heights were 158.4 cm. 111.3c.m, 104.3cm and 95.4 cm respectively.

Joshi *et al.* (2006) evaluated the ricebean accessions in field for phenology, yield component and insects and disease reactions during the cropping season. Based on maturity rice bean accessions divided into early, medium and late. The plant height of early, medium ,and late rice bean germplasm are 190-212cm ,119-273cm,129-263 cm with mean values 199,186.7 and 195.3 cm respectively.

Arshad Ullah *et al*. (2010) conducted study at national agriculture. Research center (NARC) Islamabad to investigate the performance of summer forage legumes including cowpea , lablab bean, ricebean and sesbania .The objective of the study was to determine forage field and quality in terms of crude protein in selected forage species among four legumes plant height, fresh and dry matter yield and crude protein yield in rice bean and cowpea were 86c.m, 12.8 t ha^{-1}, 2.6 t ha^{-1}, 20.3%, 533 kg ha^{-1} and 116 cm, 11.7 t ha^{-1}, 2.4 t ha^{-1} 20.9% and 415 kg ha^{-1} respectively highest dry weight (3.9 t ha^{-1}) was obtained by sesbania as well as highest crude protein content 581 $kgha^{-1}$.

Katoch (2011) studied the genotypic response of the growth, yield and quality traits of rice bean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] to N,P,K enrichment was studied in relation to different fertilizer treatments. The treatments consisted of three N,P,K levels, namely 0:0:0 (T_0) control, 10:30:10 (T_1) and 20:60:20 (T_2) kg ha^{-1}. There were significant differences in plant height 115 days after sowing, days to maturity and tryptophan content (g/16 g N) in various rice bean genotypes with different fertilizer levels. Higher seed yields were recorded for the genotypes JCR-20(S), IC-140796, IC-019352 and JCR-152 as compared to the check variety (BRS-2). The fertilizer treatments significantly affected growth, yield and its contributing traits: plant height, number of pod clusters/plant, seeds/pod, seed yield/plot and total pods picked at maturity. Little variation was observed between the fertilizer treatments for the crude protein (%) and methionine (g/16 g N) contents, but significant variation in the tryptophan content was detected for genotype LRB-40-2. Seed yield and its contributing traits responded positively to the fertilizer treatments. Among the three fertilizer treatments tested in the experiment, the T_2 treatment was found to be promising for increasing seed yield. Thus, it can be concluded from the study that the rice bean crop is responsive to fertilizers and that the application of optimal levels of NPK could enhance its productivity.

2.6 Number of Nodule

Katoch (2010) conducted studies to determine the effect of different levels of N.P. and K on nodulation and quality traits of fodder in rice bean genotypes. The treatment consisting of NPK levels vi2, 0:0:0 (To), 10:30:10 (T_1), 20:30:20 (T_2), kg/ha exhibited significant differences amongst the genotype in nodulation. Genotypic response of rice bean to rhizobium sp. was studied in terms of nodule no. and fresh weight (g) under different fertilizer treatments. Genotype 1c- 140796 was observed to have significantly high number of nodule and fresh weight (j) where as 1c-137200 and

JCR-107 had significantly lower number of nodule in comparison to the check (BRS-2) Fertilizer treatments significantly affected nodule number and weight crude fiber and total ash increased significantly in the fodder samples with N.P. and K where as crude protein content showed was recorded at 50 kg ha^{-1}. The plant height was (158.3cm) at this level. The variety BR-99 produced significantly higher forage field (63.00 t ha^{-1})

2.7 Germplasm influence on Number of Nodules and weight of Nodule.

Luse *et.al*. (1975) studied the effect of different levels of phosphorus on nodulation of cowpea and noted that nodulation activity (numbers and weight of nodules/plant) and seed yield in cowpea increased with increasing does of phosphorus.

Mukherjee *et. al.* (1998) studied 4 cultivars of *Vigna umbellata* which were grown in sandy loam soil and given 0, 30, 60 or 90 kg P_2O_5 + 40 kg K_2O and 20 kg N fertilizer ha^{-1} and crop growth was analyzed. Significant differences were found between cultivars with highest dry matter yields obtained with cultivar V4, followed by V1. Yield, nodulation and crop growth increased with increase in applied P.

Ikombo *et.al.* (2000) noted the effect of phosphorus level on growth and nodulation of cowpea cv. Vita 4 and IFe brown in pedzolic soil. The number of leaves and dry matter field in both cultivars increased with increasing phosphorus application. An increase in phosphorus from 20 to 160 kg/ha recorded the increase in number of nodules/plant from 16 to 113 in vita 4 and from 14 to 70 in Ife brown. Similar trend was followed by nodule dry weight.

2.6 NUTRIENT COMPOSITION

Bishap *et al.* (1976) studied the effect of different levels of N,P,K on protein and yield of three legumes i.e. Soybean, field peas and faba beans and revealed that fertilizer had minimal effect on the percentages of N, P, K, Ca and Mg in leaf tissues .the most consistent effect was a decrease in leaf Mg with increasing rates of K.

Mohan and Janardanan (1994) studied two germplasm of the tribal pulse *Bauhinia recemosa* L. and were analyzed for proximate composition ; crude protein ,crude lipid ,ash ,and nitrogen free extractives constituted 19.84%, 9.52%, 3.31%, and 60.65% respectively in forest germplasm, whereas in wildlife sanctuary germplasm they constituted 19.3%, 8.94%, 3.81% and 61.30% respectively.

Mohan and Janardanan (1994) reported that the crude protein content in ricebean varied between 21.9% - 26.1%.

Vedival and Janardanan (2000) analyses 7 accessions of underutilized legume for the proximate composition and found that crude protein content ranged from 15.52 to 20.74% ,potassium was most abundant mineral *i.e.* 1029-1786 mg/100g where as manganese was low i.e. 2.1 to 2.2 mg/100 gm.

According to Saharan *et.al* (2000) the amount of HCl extractable Ca, P, Zn, and Fe content in row seeds of rice bean and faba bean were (70.2 , 50.2) ,(78.0,71.2) , (33.4,35.1) respectively.

Vedival and Janardanan (2002) collected samples of 4 accessions of lesser known legumes and were evaluated for composition , crude protein ranges from 18.56-22.93% Na , K, Ca, Mg ,P, Fe, Cu, Zn and Mn ranged from 42.92-84.3 , 758.05-1555.79 , 559.92-791.72 , 456.36-709.47 , 629.13 – 947.79 , 8.42 – 12.35 , 0.93 – 2.06 , 10.66 - 30.4 and 2.12 – 4.12 mg/100 gm seeds respectively.

Kaur and Kawatra (2002) found total iron content values varies between 7.5 and 8.3 mg/100 gm in ricebean.

Khabiruddin *et. al*.(2002) evaluate the promising genotypes of rice bean (V. umbellata) for its proximate composition and to select nutritionally superior genotypes. Protein content varied from 15.8 to 19.0%. The genotypes RBL-33-1, RBL-35, RBL-99, KHRB-2 and SRBS-50 had high protein content (>18%).

Shrivastava *et. al.* (2002) studied nutritional quality of 17 genotypes of rice bean (*V. umbellata*) was studied. The protein content ranged from 20.34 to 22.97%. Soluble sugar ranged from 1.24 to 2.52%. The polyphenols were very low and ranged from 0.08 to 0.16%. The ether extractive was present in the range 1.97-3.73%. The phosphorus (290-440), zinc (2.69-3.37), copper (0.55-1.20) and iron (5.46-7.49) mg/100 g were present in the seed of rice bean. Rice bean is comparable, in terms of quality attributes, to other traditional pulses.

According to Favaro *et.al* (2007) Ca concentration in shoot of the Snap bean cultivar UFL 1 is 180 mg per gm on dry matter basis.

Awasthi *et.al* (2011) analyses 12 rice bean varieties in protein digestibility , tannins , cooking time, Ca , Fe , Zn , and P Ranged from 17.9 to 19.4 , 0.48 to 1.15 , 4.6 to 6.7 , 3.9 to 5.7 , 58.0 to 61.2 % ,0.98 to 1..50 , 0.84 to1.36 mg/100 gm protein 83.3 to 88.5 % ,490 to 860 mg /100 gm , 44 to 56 min. 256 to 385 , 3.6 to 7.4 , 2.4 to4.2 and 273.3 to 517.9 mg /100gm respectively.

2.7 FODDER YIELD OF RICE BEAN

Mukherjee *et al.,* (1980) reported that rice bean had the potential to produce 30 q ha^{-1} seeds and could produce up to 80 q ha^{-1} dry herbage to meet scarcity of green forage during the lean period i.e. April – June and November – December.

Arya and Singh (1994) from the field studies at Tehri Garhwal (U.P) India indicate that on an average, the grain (12.04 q / ha) and straw (68.70 q /ha) yields of rice bean significantly increased up to 40 P_2O_5 / ha. However the interaction effect showed that grain yield of rice bean was still higher with the application of acidulated rock phosphate @ 60 kg P_2O_5 / ha.

Field studies at Faisalabad Pakistan revealed that green fodder yield were maximum (50.35,51.61 and 53.03 t/ ha)in plots fertilized with 50 kg N and 25,50 and 75 kg P_2O_5/ha. crude protein fibre and ash contents of rice bean were increased with increasing rates of N and P, Iqbal *et al.*(1998).

Mukherjee *et al.(1998*) Reported from field study at Gayneshpur ,West Bengal it was noticed that the seed yield of rice bean ranged from 1.37 to 2.07 t/ha with the variations in P –levels from 0 to 90 kg P_2O_5 ha^{-1}

Mandal and Mukherjee (1999) from a field experiment in Mohanpur (India) showed that rice bean CV .S_9,BC-2,F_2 KX9 and S_3 produced green herbage yield of >15 t/ha ,while S_9, BC-2 and S_3gave dry matter yield of >3 t/ha and BC-2 give crude protein yield of 0.3 t/ha.

From a two year experiment on rice bean (CV Hazra) during kharif season in tarai region of West Bengal ,Pradhan *et al.(2000) observed that* the highest quantity of green fodder (18.7 t/ ha) , dry matter (2.11t/ ha).mineral matter content (236.71 kg/ha) and silica content (106.07kg/ha) in mineral matter were obtained at the highest level of phosphate (60 P_2O_5 kg ha^{-1}) the crop harvested at 75 DAS produced the highest value of all these parameters.

Praveen *et. al.* (2001) recorded forage yield and quality of rice bean legume in the Pothwar platue of Pakistan the results are ,plant height-109.2 cm, Forage yield on fresh weight basis 22.3 t ha^{-1} and dry weight basis 4.85 t ha^{-1},crude protein content recoded 20.1%.

According to Oomen and Sumabai (2002) Rice bean has high fodder production potential up to 35 tones ha^{-1},it is now attracting attention as a leguminous fodder crop.

Rudragouda *et. al* (2005) reported from field experiment conducted at Dharwad ,Karnatka indicate that higher green and dry forage yield and better crop qualities of ricebean can be obtained with KHRB-1 genotype at an application of 30:70:35 kg $N:P_2O_5:K_2O$ ha^{-1}.

Dua *et al.*(2003) studied the fodder yield of ricebean in four districts Ludhiana, S.K. Nagar, Bangalore and Bhubaneswar in q ha^{-1} which was reported to be 145.0, 11.26, 70.15, 14.36 respectively.

Khan *et al.*(2004) studied the performance of different summer fodder as intercrops in cotton was studied at the Agronomic research area, University of Agriculture ,Faisalabad (Pakistan) maize, sorghum, rice bean and cowpea fodder were intercropped in the space between 80 cm. apart single rows as well as 120 cm spaced double row of strips of cotton .the highest yield significant fresh fodder yield (16.82 t ha^{-1}) was recorded in the sole rice bean crop. This was recorded in the sole rice bean crop. This was followed by intercropping of rice bean in 120 cm apart double row strips of cotton (P_2) with 12.57 t ha^{-1} fresh fodder yield. Reduction in fresh fodder yield was 59.6 and 25.3% for P_2 and P_1 respectively Afield experiment was conducted at the agronomic research area, University of Faisalabad , during 2001 to evaluate the effect on growth ,yield and quality of sorghum fodder (*Sorghum bicolor L.*) sown alone and in mixture with ricebean (*Vigna umbellata*). The sorghum and rice bean were sown at proportion of 100:0 , 0:100 , 50:50 , 65:35 , 75:25 , 35:65 and 25:75.The seed rate of sorghum and rice bean was 80 kg and 20 kg ha^{-1} respectively. The mixture seed rates were made on that of pure stand. The green fodder yield at above seed proportion 68.09, 40.92, 61.97, 64.09, 68.51, 60.58 and 55.06 t / ha respectively. Ayub *et al.* (2004)

Khan *et al.* (2005) In variety screening trial cowpea conducted under rainy condition at Kohat division (Pakistan) during Kharif season. On an average of two years maximum green fodder yield 20.44 t ha^{-1} was recorded for variety P-518 followed by SWC-31and SWC-8 producing 16.72 and 16.11 t/ha fodder yields respectively.

Udragolia *et al.* (2008) conducted field experiment at Dharwad during kharif to study the effects of genotypes, fertility levels on growth and yield of ricebean for fodder, Plant height , number of trifoliate leaves, leaf area index, dry matter per plant and eventually green forage yield (13.47q ha^{-1}) and dry forage yield (2.43 t ha^{-1}) were found to be increase significantly when the crop was fertilized with of 35 kg ha^{-1},70 kg P_2O_5 ha^{-1} and 35 kg K_2O ha^{-1}.

MATERIALS AND METHODS

The present investigation entitled “Screening of rice bean (*Vigna umbellate* L.) germplasm for their growth, quality and nitrogen fixing efficiency˝ was carried out during rainy (*kharif*) seasons of 2011 at the Research Farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, India. A detailed account of the materials used, experimental procedure and methods adopted during the course of field investigation are described in this chapter.

3.1 Location of the Experimental Site

Jabalpur is situated in the south-eastern part of Madhya Pradesh at 23^0 13’ Northlatitude, 79^0 57’ East longitudes at an altitude of 393 meter mean sea level. Experimental field was prepared well with even topography and uniform textural make up. The field was attached to the main irrigation channel connecting the farm tube well for quick, regular and timely irrigation. Proper drainage facility was also provided in order to remove excess and unwanted water during experimental period.

3.2 Soils of the Experimental Field

The soil, as a medium of plant support and growth, is bound to affect profoundly the rate of growth as well as development and eventually the final and economic yield through its biotic and abiotic activities associated with chemical properties. To determine the initial fertility status of soil after the field preparation and before layout of experiment, the composite samples from 0-15 cm depth were randomly collected from the experimental field with the help of screw auger. All the possible technical precautions as prescribed for standard soil sampling were also taken. Samples were brought to the laboratory, air-dried in the shade and grounded by wooden roller, there after sieved through 2 mm mesh and stored in polyethylene bags. The soil samples thus obtained were subjected to various chemical and biological analyses to assess the single value chemical and biological properties of soil.

The soil of the experimental site was Vertisols belongs to fine montmorillonite, Hypothermic family of *Typic Haplusterts* popularly known as “black soil”. The soil chemical and biological properties were presented in Table 3.1:

Table 3.1: Chemical and biological properties of initial soil sample.

Properties	Values	Method employed
Soil pH	7.66	Glass electrode pH meter (Jakson, 1973)
Electrical conductivity (dS m^{-1} at 25 ^{0}C)	0.354	Electrical conductivity meter (Jackson, 1973)
Organic carbon (%)	6.13	Walkley and Black rapid titration method (Walkley and Black, 1934)
Available nitrogen (kg ha^{-1})	163.1	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus (kg ha^{-1})	12.75	(Watanabe and Olsen’s, 1965)
Available potassium (kg ha^{-1})	374.18	Neutral normal ammonium acetate method by using flame photometer (Jackson, 1973)
Available Ca^{+2} (mg kg^{-1}) Available Mg^{+2} (mg kg^{1})	18.24 10.3	Determined by Versenate (EDTA) method (Black, 1965)
Available sulphur (kg ha^{-1})	7.85	Turbidimetric method (Chesnin and Yien, 1951)
Available Cu (mg kg^{-1}) Available Mn (mg kg^{-1}) Available Zn (mg kg^{-1}) Available Fe (mg kg^{-1})	1.36 8.45 13.63 13.3	By atomic absorption spectrophotometer (Lindsay and Norvell, 1978)

Microbial properties	Population/g oven dry soil	By serial dilution plate count method (Subba Rao, 1986)
Total Bacteria Count	17.45×10^5	Thornton's medium for total bacterial count (Thornton,1930)
Actinomycetes	13.30×10^2	Caseinate Agar medium for actinomycetes (Rao, 1988)
Fungi	15.25×10^3	Rosebengal streptomycin agar media for fungi (Rao, 1988)

3.3 Climate and Weather

Jabalpur is situated in the south-eastern part of Madhya Pradesh at 23^0 13' North latitude, 79^0 57' East longitudes at an altitude of 393 meter mean sea level. The tropic of cancer passes through the middle of the district. It has sub-tropical climate characterized by hot dry summers and cool dry winter. Jabalpur lies in the "Kymore Plateau and Satpura Hills" agro climatic zone of Madhya Pradesh. The average maximum temperatures during the month of May-June varies between 42.5 to 46.4 ^{0}C and are the hottest month of the year, while the average minimum temperature varies between 4.2 to 8.7 ^{0}C during December-January, which are the coldest month of the year. The average annual seasonal rainfall of this region is about 1200 mm which is mostly received between June to September and a little rainfall (75 to 175mm) received in the month from October to May. The average humidity of the region is about 73 per cent and average evaporation is 3.93 mm/day.

Table 3.2 : Weekly meteorological data during 2011-2012.

Month	Weeks	Temperature		RH %		Rainfall (mm)	No. of rainy days	Sunshine hours
		Max	Min	Max	Min			
June	23	40.1	26.4	61	28	15.4	1	7.4
	24	39.6	25.2	73	37	23.4	3	6.2
	25	31.0	22.5	89	84	253.2	5	2.8
	26	27.4	22.8	90	80	91.3	4	0.4
July	27	32.8	23.8	86	61	15.2	2	4.9
	28	32.0	23.5	92	71	46.4	3	3.1
	29	30.3	22.8	93	83	429.1	6	2.5
	30	29.9	22.7	90	70	119.2	3	9.4
August	31	31.1	23.6	92	82	140	5	3.9
	32	28.7	22.7	93	85	118.5	6	1.5
	33	29.8	22.7	92	78	57.6	3	4
	34	30.9	22.9	93	70	14.6	3	6.3
September	35	31.5	22.8	96	71	150.6	7	5.8
	36	29.5	22.6	94	80	221.6	4	1.2
	37	29.7	22.4	93	73	92.2	3	3.9
	38	30.8	21.9	93	67	41.0	4	5.1
October	39	31.3	20.8	86	56	00	0	6.9
	40	32.2	18.6	90	54	5.2	1	9.0
	41	32.4	19.1	92	43	00	0	8.3
	42	32.6	15.8	89	31	0	0	9.3
November	43	31.8	13.9	87	30	0	0	8.9
	44	31.0	11.0	86	24	0	0	9
	45	31.8	12.1	89	29	0	0	8.3
	46	30.9	12.4	89	28	0	0	8.0

Source: Department of Meteorology, College of Agricultural Engineering, JNKVV, Jabalpur (M.P.)

3.4 Technical Programme

3.4.1 Experimental Layout

The experiment was laid out in accordance with principle of experimental design and conducted during rainy (*kharif*) season of 2011, forty different germplasms of Rice bean were taken. To evaluate the best of them details of the layout plan and various germplasms are given in Table 3.3.

Table 3.3(a): Details of the layout.

Experimental design	-	RBD
No.of germplasm under study	-	40
Number of replications	-	3
Number of rows	-	40
Gross plot size	-	3.0 m x 4 m ($12m^2$)
Net plot size	-	2.5 m x 3.5 m = 8.75 m^2
Row to row spacing	-	30 cm
Plant to plant spacing	-	10 cm
Seed rate	-	35(kg ha^{-1})
Width of separating bund	-	30 cm
Width of main irrigation channel	-	1 m
Width of sub-irrigation channel	-	80 cm
Block border	-	1.25 m
Plot border	-	1.0 m

Table 3.3: (b)- Details of Germplasms under study.

S.NO.	INDICATION	GERMPLASM
1	G-1	BFRB-3
2	G-2	BFRB-3-1
3	G-3	KRB-86
4	G-4	KRB-86-1
5	G-5	KRB-99
6	G-6	KRB-99-1
7	G-7	BFRB-57
8	G-8	BFRB-5-2
9	G-17	BIDHAN-1-1
10	G-18	BFRB-8-1
11	G-19	IRB-6
12	G-20	BFRB-9
13	G-21	KRB-19-1
14	G-22	BFRB-10
15	G-23	KRB-128
16	G-24	KRB-235
17	G-33	JR06-4-1
18	G-34	JR06-5-1
19	G-35	JR06-6
20	G-36	JR06-7
21	G-37	JR06-8
22	G-38	JR06-8-1
23	G-39	JR06-8-2
24	G-40	JR06-9
25	G-49	JRB07-3
26	G-50	JRB07-4
27	G-51	JRB07-11
28	G-52	JRB01-11-1
29	G-53	JRB07-33
30	G-54	JRB07-33-1
31	G-55	JRB07-33-2
32	G-56	JRB07-34-1
33	G-65	JRB07-43-3
34	G-66	JRB07-43-4
35	G-67	JRB07-48-1
36	G-68	JRB07-49-1
37	G-69	JRB07-50-1
38	G-70	JRB07-50-2
39	G-71	JRB04-51-1
40	G-72	JRB07-28-1

3.4.2 Morphological characters

Three plants were selected randomly in each row and tagged for recording observations. Almost all the morphological characters were recorded at 45 DAS and at harvest during the experimental year.

3.4.2.1 Plant height

The height of plant was measured from randomly three tagged plants at 45 DAS and at harvest of crop from the base of the plant to the tip of the top most leaf with the help of measuring scale. The plant height was expressed as average plant height in cm.

3.4.2.2 Total plant weight

The plant weight of tagged ricebean plants randomly selected in net plot area at both the growth stages are weighed to get fresh weight of plant and the average value was computed at 45 DAS and at harvest.

3.4.2.3 Dry weight per plant

After recording the fresh plant biomass, plants were subjected to air dry and then dried in a hot air oven at 60^0C for 1-5 days (till constant weight) to record the dried plant biomass. After recording the weight the dried plant samples were ground in electric grinder for further analytical work

3.4.3 Nodulation

3.4.3.1 Number of nodules

Nodulation studies were done at 45 days of sowing by uprooting 5 plants/plot very carefully taking sufficient care to avoid any losses or damage of root nodules. The rhizosphere soil was washed in the running water. After proper washing per plant nodules were counted manually and weighted.

3.4.3.2 Oven dried weight of nodules

After counting, the nodules were detached from the roots and were kept in small paper bags, the nodules were oven dried in hot air oven at 60±5^{0}C for 3-4 days (till constant weight) to record their oven dried weight.

3.4.3.3 Nutritional parameters

The ricebean samples collected at 45 DAS and at harvest and were analyzed for nutrient contents as well as their uptake.

3.5 Preparation of plant samples

Ricebean fodder sample collected at 45 DAS and at harvest were dried in open air for few days and dried in hot air oven at 60 ± 2^o C to get a constant weight of the sample. After drying, whole plant was powdered with the help of a grinder, passed through 2 mm sieve and used for chemical assay.

3.5.1 Digestion of plant samples

Plant samples were subjected to diacid mixture for the digestion of collected samples at 45 DAS and at harvest. One gram of dried and ground samples was placed in a conical flask. To this, 10 ml of diacid mixture (HNO_3 and $HClO_4$ in a ratio of 9:4) was added to flask tube and the flask was mixed by swirling and kept on hot plate overnight for pre digestion. The flask were placed on hot plate in digestion chamber at higher temperature (160 ^{0}C) with contents was converted in to transparent liquid and volume reduced to about 3 to 5 ml which conforms the completion of digestion. After cooling the content, it was diluted with glass-distilled water and volume was made to 100 ml volumetric flask. Aliquots of this solution were used for the determination of P, K, Ca, Mg, S, Cu, Zn, Mn, and Fe as per standard procedures (Table 3.4).

Total nitrogen was estimated by the micro-kjeldahl method as per procedure suggested by AOAC (1995).For the digestion of plant samples,0.5 gm or 1 gm of sample was taken in the digestion tube ,add 10 ml of concentrated sulfuric acid and 5 gm of digestion mixture .the digestion tubes were loaded in the digester a 100°C temperature ,maintain the block temperature between 360°C to 410°C .the samples turns light green colour or colourless at the end of the digestion process.

Table 3.4: Methods of plant chemical analysis.

Particulars	**Analytical method**	**Method employed**
Nutrient contents		
Nitrogen (%)	Micro – Kjeldahl method	AOAC (1995)
Phosphorus (%)	Vanado molybdate yellow colour method	Bhargava & Raghupathi (1984)
Potassium (%), Ca & Mg (mg kg^{-1})	Flame-photometric method	Bhargava & Raghupathi (1984)
Sulphur (%)	Turbidimetric method	Bhargava & Raghupathi (1984)
Zn, Mn, Cu & Fe (mg kg^{-1})	Atomic absorption spectrophotomer method	Bhargava & Raghupathi (1984)

Nutrient uptake (kg ha^{-1})

Nutrient uptake of different nutrients i.e. N, P, K, Ca, Mg, S and micronutrients Cu, Zn, Mn, and Fe by rice bean was calculated in kg ha^{-1} by using the following formula.

Nutrient Uptake (kg ha^{-1}) = Nutrient content (%) x fodder yield (kg ha^{-1})

3.5 Soil analysis

Surface soil samples (0-15 cm depth) were collected from each plot after the crop harvest and mixed thoroughly, composite samples were prepared and analyzed for pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and micronutrients like copper, zinc, manganese and iron content during the experimental year as per standard laboratory procedures (Table 3.1).

3.6 Microbial study

To enumerate presence of bacteria in a sample serial dilution is followed to count the organisms. Since other methods like microscopic count, electric cell count, chemical and spectrophotometric method count both living and dead cells. This method can not differentiate between living and dead cells. Therefore, serial dilution agar plating method, which enumerate only the viable bacteria cell. It is the universally used method for counting living viable cells in different samples.

3.6.1 Serial dilution

For plating purpose the collected soil sample were brought to room temperature then serial dilution were made by suspending 10 gm of soil sample in 90 ml sterilized distilled water in flasks and were shaken on horizontal shaker for 20 min. which resulted in 10^{-1} dilution. Subsequent serial dilution was made upto 10^{-6} dillution for plating purpose.

3.6.2 Plating

Plating was done by taking 1ml each of 10^{-1} to 10^{-6} dillution depending upon the type of micro-organisms to be counted in sterilized petriplates. Plating was done in triplicate for each dilution.The composition of standard media for actinomycets , becteria and fungi were taken respectively are described below:-

Rose Bengal Streptomycin agar media for Fungi: (Rao, 1988)

Glucose	-	10 g
Peptone	-	5 g
KH_2PO_4	-	1 g
$MgSO_4$	-	0.03 g
Agar-Agar	-	15 -18 g
Distilled water	-	1000 ml

Caseinate Agar media for actinomycetes (Rao, 1988)

Sodium Caseinate	0.2 g
K_2HPO_4	0.5 g
$MgSO_4$	0.2 g
$FeCl_3$	0.01 g
Agar-Agar	15-18 g
Distilled water	1000 ml

Thorntons media for total bacteria count (Thornton,1930)

$MgSO_4$	0.2 g
$CaCl_2$	0.1 gm
$FeCl_2$	Trace
NaCl	0.1 gm
KNO_3	0.5 gm
Asparagin	0.5 gm
Mannitol	1 gm
Yeast extract	Trace
Agar-Agar	15-18gm
Distilled water	1000 ml

In this technique 1 ml of the bacteria suspensions is dropped onto a sterilized petridish and then liquefied nutrient agar medium is poured over it the petridish is then gently swirled to make the suspension spread uniformly on agar plate and allowed to cool. After solidification of media the plates were inverted and incubated at 28±2°c for 24-48 hrs. After incubation period colonies that appears as white, yellow with pigments on kings B medium, water drop like colonies with light brown to black pigments on jensons medium, mycelial growth on Rose Bengal medium and white centered solublized like structure (Actinomycetes colonies) on Caseinate medium were counted.

3.8 Statistical analysis

The data pertaining to each character of the ricebean were tabulated and analyzed statistically by applying the standard technique. Analysis of variance for randomized block design was worked out and the significance was tested to draw valid conclusions as described by Gomez and Gomez (1984).

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RESULTS

After analysis of soil and plant samples collected during experimentation at different growth stages of 40 ricebean cultivars have been tabulated and screened out to estimate their growth quality and nitrogen fixing efficiencies, chemical composition, nutrient uptake ,growth attributing characters, nodulation characteristics ,fodder yield, different soil properties at 45 DAS and at harvest are the contents in this chapter.

4.1 Morphological characters and fodder yield

Data related to morphological characters like plant height, dry matter per plant and fodder yield on fresh weight basis as affected by different genotypes at active growth stages 45 DAS and at harvest.

4.1.1 Plant height (cm)

Data on comparative plant height as influenced by different germplasms at 45 DAS and at harvest stage are presented in Table 4.1. It is evident from the data that there was marked significant difference in plant height of various germplasms. Plant height increased linearly with the advancement of growth stages when recorded at 45 DAS and at harvest. Plant height observed to range from 7.80 to 25.33 cm with the mean value of 14.33 cm .The highest plant height was recorded in the germplasm G-68 (25.33 cm) followed by G- 49 and G-19 and lowest in G-40 (7.80cm) at 45 DAS. The maximum height was observed in the G-68 (108.14cm) followed by G-3 (95.33cm) and lowest in G-40 (34.29 cm) cultivar at harvest stage with mean of value 59.07cm.

4.1 Effect of different germplasms on Plant height, Dry Matter, Moisture content and Fodder Yield at 45 DAS & at Harvest

Sl. No.	Germplasms	At 45 DAS			At harvest			
		Plant height (cm)	Dry Matter $Plant^{-1}$ (g)	Moisture content (%)	Plant height (cm)	Dry Matter $Plant^{-1}$ (g)	Moisture content (%)	Fodder yield (q ha-1)
1	G-1	14.21	0.88	87.69	52.25	40.49	81.47	152.67
2	G-2	15	1	81.13	90.12	71.26	77.46	265.32
3	G-3	18.17	1.17	86	95.33	48.9	80.53	164.54
4	G-4	12.67	0.8	88.24	72.22	63.81	80.78	260.92
5	G-5	9.8	1.13	83.57	58.38	55.26	78.26	287.41
6	G-6	10.33	0.83	89.58	60.31	67.17	81.76	273.33
7	G-7	10.33	0.97	87.11	57	35.61	80.15	95.39
8	G-8	10	0.71	93.12	48.27	59.7	84.15	181.12
9	G-17	19.67	1.17	87.04	60.18	58.13	79.67	227.75
10	G-18	17	0.63	87.9	90.3	56.11	81.55	241.23
11	G-19	24	1.15	85.02	93.34	64.32	78.6	253.45
12	G-20	17.33	1.00	87.91	48.43	41.18	81.68	173.83
13	G-21	13.67	1.13	87.86	57.11	42.15	80.9	174.17
14	G-22	11.33	1.33	83.67	47.5	35.97	80.41	146.14
15	G-23	9.5	1.00	87.07	40.00	36.25	82.6	157.77
16	G-24	12.67	1.03	79.97	47.07	40.16	76.24	135.22
17	G-33	19.33	0.98	83.21	38.36	22.93	79.56	76.61
18	G-34	9.67	0.63	81.18	60.19	52.76	76.55	190.74
19	G-35	13.67	0.81	81.9	65.21	41.33	77.67	146.38
20	G-36	18	1.00	85.00	70.20	56.73	77.34	188.68
21	G-37	8.67	0.78	83.12	67.13	59.26	76.87	199.96
22	G-38	11.83	0.73	82.82	70.13	55.43	76.54	184.42
23	G-39	15.67	1.03	86.16	65.28	74.79	77.95	252.25
24	G-40	7.8	0.57	78.20	34.29	18.63	75.65	232.34
25	G-49	24.67	1.10	92.78	44.31	24.34	84.57	108.58
26	G-50	20.67	1.07	89.16	60.11	56.35	81.43	227.2
27	G-51	14.33	1.63	87.29	38.27	20.98	82.57	73.50
28	G-52	11	1.40	89.06	42.38	34.78	81.86	138.31
29	G-53	12	0.72	84.42	57.18	58.14	78.14	206.24
30	G-54	16.67	1.33	84.96	60.11	71.89	77.69	250.67
31	G-55	11.33	1.03	80.98	55.26	64.23	76.6	216.92
32	G-56	10.33	1.25	86.54	63.37	57.89	80.33	230.46
33	G-65	12	0.97	94.74	41.22	29.71	83.51	122.03
34	G-66	17.33	0.85	94.57	65.6	41.29	84.81	106.13
35	G-67	18	0.91	91.36	43.46	33.84	82.73	172.31
36	G-68	25.33	2.03	95.44	108.41	75.42	85.93	294.33
37	G-69	11.17	1.57	88.72	41.21	60.8	83.57	67.10
38	G-70	12.33	1.60	85.30	50.00	32.09	78.79	120.81
39	G-71	12	0.77	87.95	55.49	62.81	79.47	230.57
40	G-72	13.67	1.20	86.36	47.68	56.34	78.54	217.94
Mean		14.33	1.05	86.60	59.07	49.48	80.12	186.12
Range		7.80-25.33	0.57-2.03	78.20-95.44	34.29-108.41	18.63-75.42	75.65-85.93	67.10-294.33
SE m±		0.53	0.033	3.51	2.05	1.51	2.91	8.94
C D $_{(P=0.005)}$		1.63	0.101	10.83	6.32	4.65	8.97	27.55

4.1.2 Dry matter (g/plant)

All the germplasms differed significantly with respect of dry weight that varied from 0.57 to 2.03 g/plant at 45 DAS and 18.63 to 75.42 g/plant at harvest stage with mean values 1.05 g. and 49.48 g. respectively .The maximum value of dry matter was observed in G-68 (2.03 g) preceded to it was G-51 (1.63 g) then by G-70 (1.60 g),whereas the minimum value of dry matter was observed in G-40 (0.57 g) followed by G-34 (0.63 g) at 45 DAS. Similarly at harvest stage maximum dry weight recorded by G-68 (75.42 g) followed by G-39 (74.79 g) then by G-54 (71.89 g) and G-40 (18.63) g showed minimum dry matter content followed by G-51 (20.98 g) and G-33 (22.93 g) per plant.

4.1.3 Fodder yield (q/ha)

All genotypes differed significantly among each other. The average fodder yield was 186.12 q/ha. 10 genotypes had highest fodder yield in presented in decreasing order e.g. G-68, G-5, G-6, G-2, G-4, G-19, G-39, G-54 ,G-18, G-40. fodder yield ranged from 67.10 - 294.33 q/ha . Medium range (150-210q/ha) germplasms are G-37 , G-34 , G-36 , G-38 , G-21 , G-20 , G-67 ,G-3 ,G-23 and rest of the germplasms are poor yielding genotype performer comes under range of 67-150 q/ha.

4.1.4 Moisture

The data on percent moisture content (table 4.1) revealed that decrease in moisture content has been observed in plants with increment of growth stages which differ significantly among all the germplasms at both the stages 45 DAS and at harvest. The moisture content ranges between 78.20 - 95.44 percent at 45 DAS and from 75.65 – 85.93 percent at 45 DAS and at harvest stage with mean value of 86.60 percent and 80.12 percent, respectively.

4.2 Nodulation

Data related to number of nodules percent, dry weight of nodules and their protein content are given in table 4.2.

4.2.1 Number of nodules

The data presented in table reveals that all the germplasm nodulated profusely at 45 DAS.The nodulation by germplasm ranges between 43 to181 with mean value of 91 nodules per plant. Maximum number of nodules was recorded in G-68 (181.67) ,followed by G-66 (170.33).G-35 had minimum (43) number of nodules. For comparing the nodulation among genotypes of different maturity groups, the germplasms having 40-60 nodules per plant graded in low group,60-80 number of nodules graded to medium and > 80 numbers graded in high nodulating group, according to this grade range (G-3 ,G-4 ,G-20 ,G-23 ,G-33 ,G-35 ,G-39 ,G-53, G-55, G-68, and G-71) 11 genotypes were low nodulating while (G-1 ,G-7,G-8 ,G-19 ,G-36 ,G-54 and G-68) 7 graded to medium and rest of the germplasm were graded under high nodulating germplasms, under high nodulating group 10 genotype have good nodulation were presented in descending order e.g. G-68 >G-66 > G-51> G-49 > G-67 > G-52 > G-17 > G-56 > G-70 > G-40.

4.2.2 Dry weight of nodules (g/plant)

The weight of nodules per plant of all the germplasm differed significantly with respect to nodule weight ranged from 0.15 to 0.75 g/plant. G-68 recorded highest nodule weight (0.75 gm) followed by G-6 - 0.65 gm/plant while minimum nodule dry weight was observed in G-40 (0.15 gm/plant) followed by G-1 (0.16 gm/plant) with mean value 0.34 gm/plant.

4.2 Effect of different germplasms on nodulation & protein content at 45 DAS

Sl. No.	Germplasms	No. of Nodules $Plant^{-1}$	Dry wt. of nodules $Plant^{-1}$ (g)	Protein content of nodules (%)
1	G-1	60.67	0.16	8.52
2	G-2	85.33	0.23	8.23
3	G-3	46.67	0.27	7.34
4	G-4	43.36	0.21	9.11
5	G-5	116.67	0.54	7.34
6	G-6	80.33	0.65	6.76
7	G-7	70.67	0.51	7.17
8	G-8	60.33	0.23	9.4
9	G-17	136.67	0.48	16.16
10	G-18	115	0.53	13.81
11	G-19	61.33	0.25	9.4
12	G-20	46.67	0.2	14.75
13	G-21	90.37	0.37	16.33
14	G-22	86.67	0.32	6.29
15	G-23	52.67	0.3	9.69
16	G-24	88.67	0.34	7.21
17	G-33	53.33	0.27	14.86
18	G-34	80.33	0.25	16.92
19	G-35	43.33	0.19	14.22
20	G-36	78.33	0.43	9.69
21	G-37	115.67	0.4	12.25
22	G-38	83.33	0.28	9.99
23	G-39	52.33	0.21	6.76
24	G-40	117.67	0.15	14.1
25	G-49	160.67	0.29	9.15
26	G-50	83.33	0.48	15.16
27	G-51	166.67	0.63	10.28
28	G-52	138.33	0.36	11.75
29	G-53	47.67	0.17	12.1
30	G-54	60.33	0.19	12.34
31	G-55	51.67	0.16	9.78
32	G-56	121.67	0.3	9.4
33	G-65	60.38	0.58	12.93
34	G-66	170.33	0.27	17.13
35	G-67	151.67	0.5	14.1
36	G-68	181.67	0.75	21.7
37	G-69	103.33	0.38	10.28
38	G-70	118.33	0.41	13.22
39	G-71	53.33	0.24	11.46
40	G-72	98.33	0.29	13.51
Mean		90.85	0.34	11.5
Range		43.33-181.67	0.15-0.75	6.29-21.17
SE m±		5.07	0.018	0.62
C D *(P=0.005)*		15.63	0.054	1.9

4.2.3 Protein content

The crude protein content in nodules of rice bean germplasm ranged from 6.29 to 21.17 percent .Genotypes root had variations in their crude protein content. Germplasms were grouped into high, medium and low , based on protein content >14% considered to be high protein content genotypes,10-15% grouped under medium and 6-10 % genotypes were considered under low protein content germplasms. Based on this category (G-68 , G-66 , G-34 , G-21 , G-17 , G-50 ,G-33 , G-20 ,G-35 ,G-40) 10 genotypes had high crude protein content.

4.3 Soil properties

Soil samples of the field were analyzed for available NPK at 45 DAS and at harvest to study the changes that occurring during the growth period.

4.3.1 Soil pH

The data present in the table 4.3. The pH in the samples collected at 45 DAS and at harvest did not show statistically significant variation, which was 7.64 and 7.58 ranging from 7.53 – 7.74 and 7.49-7.68 respectively at 45 DAS and at harvest.

4.3.2 Electrical conductivity

The EC ranged from 0.30-0.44 dsm^{-1} and 0.328-0.468 dsm^{-1} differed significantly due to germplasms having mean value of 0.363 and 0.385 dsm^{1} at 45 DAS and at harvest stage.

4.3.3 Organic carbon

The organic carbon build up due to germplasm have been observed and it was increased by 3.3 percent at harvest as compared to the status at 45 DAS.

4.3 Effect of different germplasms on EC, pH and organic carbon at 45 DAS and at harvest

Sl. No.	Germplasm	At 45 DAS			At harvest		
		pH	EC(dsm^{-1})	OC(g/kg)	pH	EC(dsm^{-1})	OC(g/kg)
1	G-1	7.61	0.407	6.84	7.53	0.439	6.22
2	G-2	7.68	0.316	5.76	7.62	0.343	5.93
3	G-3	7.6	0.348	4.8	7.57	0.364	5.27
4	G-4	7.63	0.359	6.17	7.56	0.388	6.17
5	G-5	7.58	0.306	5.27	7.51	0.331	6.24
6	G-6	7.65	0.353	5.84	7.6	0.369	5.76
7	G-7	7.66	0.334	5.8	7.59	0.364	6.2
8	G-8	7.69	0.389	6.48	7.62	0.397	6.14
9	G-17	7.65	0.367	5.31	7.6	0.39	5.84
10	G-18	7.57	0.31	4.63	7.51	0.333	5.93
11	G-19	7.7	0.342	4.85	7.68	0.361	4.52
12	G-20	7.61	0.356	5.31	7.56	0.374	5.86
13	G-21	7.68	0.366	4.81	7.66	0.385	5.3
14	G-22	7.56	0.35	4.66	7.53	0.378	5.32
15	G-23	7.63	0.411	5.8	7.57	0.401	5.81
16	G-24	7.65	0.416	5.34	7.62	0.396	5.8
17	G-33	7.7	0.347	5.8	7.6	0.375	6.33
18	G-34	7.61	0.421	6.95	7.54	0.445	6.12
19	G-35	7.55	0.358	5.93	7.49	0.378	6.21
20	G-36	7.63	0.353	5.3	7.61	0.371	5.36
21	G-37	7.71	0.34	4.78	7.66	0.369	4.8
22	G-38	7.53	0.379	5.82	7.52	0.376	5.82
23	G-39	7.64	0.334	4.8	7.62	0.355	4.54
24	G-40	7.74	0.3	4.61	7.67	0.358	4.61
25	G-49	7.68	0.402	6.9	7.61	0.428	6.3
26	G-50	7.6	0.306	4.85	7.57	0.328	4.85
27	G-51	7.64	0.33	4.66	7.57	0.358	6.32
28	G-52	7.71	0.359	4.82	7.64	0.385	5.83
29	G-53	7.73	0.389	6.22	7.66	0.413	6.24
30	G-54	7.69	0.43	6.67	7.61	0.441	6.28
31	G-55	7.62	0.302	5.32	7.56	0.364	4.9
32	G-56	7.7	0.337	4.85	7.63	0.363	5.88
33	G-65	7.65	0.434	6.98	7.57	0.458	6.15
34	G-66	7.61	0.421	6.8	7.54	0.449	6.35
35	G-67	7.64	0.446	6.92	7.56	0.468	7.05
36	G-68	7.71	0.427	7.12	7.65	0.449	5.85
37	G-69	7.6	0.343	5.3	7.5	0.365	7.16
38	G-70	7.57	0.319	4.8	7.52	0.347	6.3
39	G-71	7.63	0.367	6.71	7.61	0.374	5.82
40	G-72	7.57	0.346	4.88	7.5	0.368	5.9
Mean		7.64	0.363	5.64	7.58	0.385	5.83
Range		7.53-7.74	0.300-0.446	4.61-7.12	7.49-7.68	0.328-0.468	4.52-7.16
SEm±		0.164	0.008	0.101	0.153	0.008	0.097
CD $_{(P=0.005)}$		NS	0.023	0.31	NS	0.024	0.297

4.4 Available N,P,K (kg ha-1)

The data on available N,P,K content of soil at 45 DAS and after harvesting of ricebean as fixed by by different germplasms presented in Table 4.4 which clearly revealed that available nutrient content was comparatively higher at 45 DAS as compared to at harvest stage. The fodder sample at 45 DAS and at harvest was found to have maximum content of N P and K by G-68 having 288.51,13.35 and 439.9 and 288.56, 9.96 and 413.78 kg ha^{-1} respectively. While lowest was in G-40 cultivar.

4.5 Secondary Nutrient (kg ha^{-1})

Over all in the case of available Ca, Mg and S the genotype G-68 prove to be better than other cultivars having 25.17 ,10.57 and 11.81 kg ha^{-1} respectively at 45 DAS. At harvest the content was 17.70 , 7.80 and 9.96 kg ha^{-1} of Ca ,Mg and S respectively compared to 45 DAS concentration.

4.4 Effect of different germplasms on primary nutrient content in soil

Sl. No.	Germplasm	Primary nutrients (kg ha^{-1})					
		At 45 DAS			At harvest		
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
1	G-1	250.88	12.99	351.8	213.25	8.9	326.17
2	G-2	163.1	11.43	345.34	188.16	7.1	312.84
3	G-3	137.98	10.6	324.8	150.56	8.5	293.67
4	G-4	200.7	12.47	333.9	210.71	7.9	301.5
5	G-5	150.53	10.73	318.94	213.65	7	284.87
6	G-6	175.62	12.33	321.52	163.1	7.4	285.34
7	G-7	163.1	11.81	310.47	200.71	9.7	290.19
8	G-8	225.79	12.84	345.42	238.34	6.7	320.61
9	G-17	150.53	10.43	317.24	175.62	5.58	290.91
10	G-18	125.44	9.41	290.2	163.1	5.7	264.42
11	G-19	137.98	11.9	340.15	125.44	5.53	309.15
12	G-20	150.53	11.72	331.42	163.1	6.67	298.45
13	G-21	137.98	10.85	310.8	150.55	8.44	289.45
14	G-22	125.44	10.11	302.58	150.56	8.63	277.16
15	G-23	163.1	11.67	372.46	176.22	8.4	353.27
16	G-24	150.53	11.37	334.26	175.62	8.55	315.25
17	G-33	175.62	12.13	368.25	265.43	9.68	350.47
18	G-34	263.55	13.1	378.34	238.74	7.61	354.78
19	G-35	188.16	12.51	373.9	213.25	8.52	352.74
20	G-36	150.53	11.55	355.42	150.53	8.71	329.8
21	G-37	137.98	9.95	323.65	137.99	5.61	295.4
22	G-38	163.1	11.55	332.9	163.1	5.78	302.84
23	G-39	137.98	11.25	311.9	112.9	5.68	281.45
24	G-40	125.44	8.74	287.45	112.9	5.45	262.35
25	G-49	263.42	12.24	383.74	213.25	8.35	366.19
26	G-50	137.98	10.98	364.25	137.99	7.36	340.2
27	G-51	125.44	8.95	287.6	213.55	9.23	274.45
28	G-52	137.98	9.74	344.7	175.62	7.98	328.17
29	G-53	200.7	12.6	362.87	200.71	5.92	337.64
30	G-54	238.34	12.93	380.42	213.25	5.46	353.47
31	G-55	150.53	11.17	314.4	137.95	5.73	289.7
32	G-56	137.98	9.83	304.78	163.1	6.15	278.17
33	G-65	275.95	13.3	428.7	238.34	8.5	405.76
34	G-66	250.88	12.87	418.35	263.43	8.75	402.53
35	G-67	263.42	13.18	427.53	275.97	6.8	405.28
36	G-68	288.51	13.35	439.9	288.56	9.96	413.78
37	G-69	150.53	9.21	318.63	175.62	5.8	304.19
38	G-70	137.98	9.13	312.44	213.25	7.99	294.73
39	G-71	225.79	12.73	356.79	163.1	6.93	328.61
40	G-72	147.98	10.3	312.15	175.62	7.12	284.3
Mean		176.87	11.4	343.51	187.24	7.39	318.76
Range		125.44-288.51	8.74-13.35	287.45-439.9	112.90-288.56	5.45-9.96	262.35-413.78
SEm±		3.22	0.2	6.36	3.283	0.127	5.692
$CD_{(P=0.05)}$		9.9	0.616	19.58	10.111	0.392	17.532

4.5 Effect of different germplasms on secondary nutrient content in soil

Sl. No.	Germplasm	Secondary nutrients (kg ha^{-1})					
		At 45 DAS			At harvest		
		Calcium	Magnesium	Sulphur	Calcium	Magnesium	Sulphur
1	G-1	24.45	9.86	11.46	10.14	4.53	9.24
2	G-2	23.67	9.48	11.18	16.98	7.2	6.43
3	G-3	20.47	8.09	10.48	6.35	3.15	8.25
4	G-4	24.17	9.79	11.22	16.68	7.58	6.9
5	G-5	20.2	8.21	10.4	14.55	6.65	3.25
6	G-6	23.87	9.36	11.13	17.7	7.8	5.1
7	G-7	23.76	9.21	10.96	8.64	3.88	9.96
8	G-8	24.3	10.57	11.24	10.51	5.11	8.67
9	G-17	20.61	8.66	9.88	11.35	5.2	5.22
10	G-18	18.79	7.8	8.93	10.46	4.72	3.34
11	G-19	23.95	9.54	10.8	16.47	6.93	5.96
12	G-20	22.58	9.07	10.68	8.35	3.74	7.4
13	G-21	20.89	8.03	11.2	5.85	2.92	7.56
14	G-22	20.34	7.68	10.15	5.67	2.75	8.75
15	G-23	23.43	10.14	11.1	9.95	4.45	8.46
16	G-24	23.15	9.81	10.98	9.48	4.16	8.68
17	G-33	23.97	9.78	11.12	9.51	4.27	9.8
18	G-34	24.1	9.53	11.55	11.42	5.1	7.71
19	G-35	23.73	9.89	11.13	9.4	4.18	7.83
20	G-36	21.58	9.38	10.91	10.14	4.52	6.48
21	G-37	19.78	7.46	10.63	6.34	3.15	5.27
22	G-38	22.65	8.68	10.83	10.18	4.41	5.88
23	G-39	21.87	8.82	10.94	15.68	7.13	3.72
24	G-40	19.5	8.09	9.92	10.93	4.94	4.16
25	G-49	23.7	9.37	10.8	8.45	3.65	7.87
26	G-50	22.83	9.13	10.59	11.92	5.55	5.35
27	G-51	20.87	8.42	9.76	6.18	2.97	9.12
28	G-52	21.37	8.72	9.98	7.15	3.2	6.84
29	G-53	23.45	9.73	10.9	10.16	5.12	4.51
30	G-54	23.9	9.68	10.96	14.88	7.21	3.98
31	G-55	21.8	8.55	10.67	11.78	5.12	4.95
32	G-56	20.17	7.44	9.88	10.25	4.43	4.17
33	G-65	24.76	10.23	11.7	11.97	5.2	9.17
34	G-66	24.34	10.4	11.13	12.21	5.45	8.78
35	G-67	23.95	9.04	11.4	8.94	4.1	6.13
36	G-68	25.17	9.95	11.81	17.5	7.78	5.26
37	G-69	20.38	8.42	9.7	6.68	3.11	8.91
38	G-70	19.98	7.66	11.57	6.83	3.27	8.15
39	G-71	22.86	8.4	11.58	12.85	5.53	5.86
40	G-72	20.65	8.36	11.42	8.77	4.4	6.14
Mean		22.4	9.01	10.82	6.73	4.86	6.73
Range		18.79-25.17	7.44-10.57	8.93-11.81	5.67-17.70	2.75-7.80	3.25-9.96
SEm±		0.407	0.158	0.193	0.118	0.082	0.118
CD $(P=0.05)$		1.254	0.487	0.595	0.363	0.253	0.363

4.6 Micronutrient content in soil (ppm)

4.6.1 Available Copper

The data recorded on available copper content in soil after harvesting of rice bean are presented in Table 4.6. The germplasms showed significant influence on available Cu content which decreased with the advancement of crop growth period. Maximum available Cu content of soil was recorded (1.44 ppm) in G-68 at both the growth stages (at 45 DAS & at harvest) respectively., whereas the minimum values (1.04 and 0.97ppm) were recorded in G-40 at 45 DAS and at harvest stage respectively.

4.6.2 Available Manganese(ppm)

The available Mn content in soil after harvesting of ricebean germplasms showed significant influence on available Mn of soil had similarly decreasing with the advancement of crop growth. Maximum available Mn content of soil was recorded (5.81 ppm) in G-68 at both the growth stages (at 45 DAS & at harvest) respectively. Whereas the minimum values (4.15 ppm) were recorded in G-40 during both growth stages , respectively

4.6.3 Available Iron (ppm)

The available Fe content in soil after harvesting of ricebean are presented in Table 4.6. The germplasms showed significant influence on available Fe content decreased with the advancement of crop growth period. The numerically maximum available Fe content of soil was recorded to be (11.47 ppm) in G-68 at both the growth stages (at 45 DAS & at harvest) respectively whereas the minimum values (8.16 ppm) were recorded in G-40 and in G-39 at both the growth stages , respectively.

4.6 Effect of different germplasms on micronutrient content in soil

Sl. No.	Germplasms	Micronutrients contents (ppm)							
		At 45 DAS				At harvest			
		Cu	Mn	Fe	Zn	Cu	Mn	Fe	Zn
1	G-1	1.31	5.66	11.35	11.62	1.25	5.47	9.1	9.94
2	G-2	1.21	5.23	9.76	9.97	1.12	5.04	8.53	9.43
3	G-3	1.18	5.11	9.51	9.8	1.15	5.62	9.14	9.83
4	G-4	1.26	5.46	9.9	10.11	1.14	5.1	9.23	9.49
5	G-5	1.12	5.22	9.64	9.87	1.06	5.38	8.58	9.88
6	G-6	1.26	5.4	9.83	10.17	1.12	5.08	8.61	9.29
7	G-7	1.22	5.25	9.81	9.96	1.31	5.71	9.3	9.98
8	G-8	1.37	5.57	10.89	11.12	1.18	5.5	9.26	9.78
9	G-17	1.21	5.15	9.5	9.81	1.15	5.05	8.68	9.45
10	G-18	1.11	4.38	8.48	8.8	1.05	5.68	8.73	9.69
11	G-19	1.28	5.27	9.52	9.85	1.02	5.13	8.64	9.63
12	G-20	1.23	5.2	9.45	9.7	1.08	5.27	8.58	10.19
13	G-21	1.2	5.1	9.39	9.62	1.14	4.91	8.52	10.11
14	G-22	1.13	4.97	9.2	9.45	1.28	5.78	9.15	10.26
15	G-23	1.24	5.28	9.81	10.13	1.2	5.57	9.21	10.3
16	G-24	1.2	5.25	9.7	9.95	1.18	5.54	8.68	10.37
17	G-33	1.28	5.33	9.68	9.92	1.34	5.81	9.32	10.43
18	G-34	1.32	5.73	10.7	10.95	1.11	5.43	9.11	10.35
19	G-35	1.3	5.41	9.87	10.1	1.15	5.65	8.61	10.46
20	G-36	1.13	5.18	9.62	9.85	1.13	5.47	9.17	10.15
21	G-37	1.07	4.93	8.82	9.11	1.12	4.94	8.55	9.73
22	G-38	1.18	5.2	9.87	10.11	1.12	5.6	8.47	10.18
23	G-39	1.21	5.12	9.73	9.93	0.97	5.4	8.54	9.25
24	G-40	1.04	4.15	8.16	8.38	0.97	4.83	8.23	9.19
25	G-49	1.28	5.46	9.91	10.15	1.22	5.67	9.08	10.1
26	G-50	1.25	5.04	9.55	9.77	1.19	5.51	8.38	9.95
27	G-51	1.2	4.73	8.6	9.84	1.35	5.46	9.24	10.4
28	G-52	1.15	4.83	8.76	8.98	1.2	5.48	9.28	10.2
29	G-53	1.35	5.5	10.56	10.78	1.03	5.41	8.65	9.98
30	G-54	1.39	5.73	10.85	11.1	1.01	5.27	8.71	9.96
31	G-55	1.3	5.27	9.74	9.98	1.06	5.23	8.6	10.1
32	G-56	1.23	4.81	9.33	9.61	1.05	4.83	8.5	9.89
33	G-65	1.34	5.8	10.98	11.18	1.28	5.53	9.37	10.36
34	G-66	1.31	5.35	10.63	10.86	1.33	5.67	9.14	9.9
35	G-67	1.33	5.48	11.21	11.37	1.22	5.58	8.75	10.26
36	G-68	1.44	5.81	11.47	11.65	1.38	5.86	9.52	10.52
37	G-69	1.07	4.9	8.28	8.6	0.98	5.3	8.45	10.3
38	G-70	1.05	4.83	8.5	8.71	1.25	5.73	9.28	10.23
39	G-71	1.36	5.28	10.6	10.8	1.09	5.37	8.23	9.82
40	G-72	1.13	4.66	9.33	9.62	1.07	5.16	8.85	9.87
Mean		1.23	5.2	9.76	10.03	1.15	5.4	8.85	9.98
Range		1.04-1.44	4.15-5.81	8.16-11.47	8.38-11.65	0.97-1.38	4.83-5.86	8.23-9.52	9.19-10.52
SEm±		0.022	0.098	0.181	0.189	0.02	0.096	0.161	0.181
CD $_{(P=0.005)}$		0.069	0.302	0.556	0.582	0.061	0.297	0.496	0.559

4.6.4 Available Zinc (ppm)

After harvesting of ricebean (Table 4.6.) The germplasms showed significant influence on available Zn content. It decreased with the advancement of crop growth period. The numerically maximum available Zn content of soil was recorded to be (11.65 ppm) G-68 at both the growth stages respectively (at 45 DAS & at harvest).whereas the minimum values (8.38 and 9.19 ppm) were recorded in G-40 and in G-5 during both growth stages respectively

4.7 Nutrient content in various Genotypes (%)

Analysis of plant samples for N, P, K, Ca, Mg and S and micronutrients (*viz.,*Cu, Mn, Zn and Fe) content of rice bean at (45 DAS and at harvest) stage of crop and their uptake as assimilated by different germplasms are presented in Table 4.7(a),4.7(b),4.8(c) and 4.9,4.10

4.7(A) Primary Nutrient content

The data presented in table 4.7 (a) reveals that the NPK content in different genotypes differed significantly.G-68 Genotype had high NPK content at 45 DAS and at harvest. Nutrient content ranging from 0.196 to 0.662 ,0.028 - 0.076 and 0.019 - 0.591 NPK content respectively at 45 DAS and content value ranged at harvest was 0.0301-0.545 , 0.038-0,078 and 0.113-0.234 percent NPK respectively were recorded. If we interpreted the data it is observed that at 45 DAS and compared with harvest data, There was depletion in the N,K content range which might be due to the dilution effect,slight increase was observed in phosphorus content. The content decreased in all the samples of NPK. However minimum NPK content observed in G-40 at 45 DAS and also at harvest.

4.7 (a) Assimilation of primary nutrients by germplasm at different stage

Sl. No.	Germplasm	Primary nutrients (%)					
		At 45 DAS			At harvest		
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
1	G-1	0.342	0.042	0.33	0.378	0.052	0.182
2	G-2	0.594	0.068	0.409	0.331	0.041	0.127
3	G-3	0.507	0.068	0.308	0.362	0.05	0.178
4	G-4	0.415	0.044	0.304	0.307	0.051	0.121
5	G-5	0.556	0.048	0.297	0.329	0.045	0.13
6	G-6	0.377	0.049	0.253	0.335	0.041	0.126
7	G-7	0.658	0.067	0.471	0.423	0.062	0.221
8	G-8	0.336	0.038	0.261	0.341	0.047	0.137
9	G-17	0.457	0.058	0.325	0.39	0.041	0.12
10	G-18	0.432	0.048	0.312	0.357	0.042	0.117
11	G-19	0.598	0.056	0.421	0.378	0.048	0.125
12	G-20	0.42	0.048	0.286	0.354	0.05	0.172
13	G-21	0.371	0.043	0.347	0.36	0.052	0.147
14	G-22	0.476	0.06	0.276	0.353	0.057	0.19
15	G-23	0.456	0.056	0.267	0.393	0.054	0.139
16	G-24	0.623	0.035	0.443	0.366	0.062	0.149
17	G-33	0.584	0.05	0.45	0.352	0.067	0.206
18	G-34	0.548	0.062	0.376	0.386	0.048	0.143
19	G-35	0.621	0.068	0.505	0.336	0.061	0.151
20	G-36	0.479	0.047	0.288	0.394	0.047	0.155
21	G-37	0.636	0.06	0.363	0.416	0.065	0.15
22	G-38	0.541	0.057	0.34	0.43	0.069	0.146
23	G-39	0.553	0.042	0.256	0.338	0.046	0.115
24	G-40	0.196	0.028	0.195	0.301	0.038	0.113
25	G-49	0.285	0.033	0.219	0.371	0.068	0.171
26	G-50	0.382	0.041	0.255	0.315	0.048	0.121
27	G-51	0.46	0.048	0.246	0.527	0.075	0.221
28	G-52	0.437	0.04	0.27	0.308	0.056	0.139
29	G-53	0.491	0.056	0.337	0.36	0.058	0.118
30	G-54	0.502	0.052	0.317	0.382	0.051	0.118
31	G-55	0.305	0.063	0.411	0.405	0.055	0.128
32	G-56	0.538	0.06	0.312	0.392	0.053	0.123
33	G-65	0.242	0.031	0.27	0.417	0.065	0.167
34	G-66	0.255	0.036	0.218	0.39	0.071	0.176
35	G-67	0.473	0.057	0.224	0.347	0.058	0.135
36	G-68	0.662	0.076	0.591	0.545	0.078	0.234
37	G-69	0.382	0.05	0.248	0.53	0.05	0.114
38	G-70	0.532	0.054	0.397	0.511	0.068	0.136
39	G-71	0.447	0.038	0.255	0.393	0.052	0.142
40	G-72	0.5	0.055	0.366	0.408	0.051	0.139
Mean		0.467	0.051	0.325	0.383	0.055	0.149
Range		0.196-0.662	0.028-0.076	0.195-0.591	0.301-0.545	0.038-0.078	0.113-0.234
SEm±		0.008	0.001	0.005	0.0061	0.0009	0.0022
CD $(P=0.05)$		0.024	0.003	0.016	0.0188	0.0026	0.0068

4.7 (B) Secondary Nutrient content

In all the genotypes had significant variation at both the growth stages .It has been observed that secondary nutrient content depleted in plants with advancement of growth stages except sulphur. Ca, Mg, and S content in plants ranged from 0.247-0.593, 0.092-0.255 and 0.015-0.050 percent and 0.030-0.263,0.012-0.110 and 0.034-0.078 percent at 45 DAS and at harvest respectively. Maximum Ca content was recorded in G-68 (0.593), followed by G-54 (0.561) then G-52 (0.536) at 45 DAS. Similarly G-68 (0.255) recorded maximum Mg content followed by G-36 (0.209), G-67 (0.208) and maximum value of S recorded in G-68 (0.050), preceded by G-1(0.044) and G-7(0.043).

4.8 Micronutrient content (ppm)

Copper- Copper content in plants of Rice bean varied from 0.105 to 0.410 ppm at 45 DAS and 0.123 to 0.241ppm at harvest. Maximum value of Cu content recorded in G-68 (0.410) followed by G-24 (0.398) and G-39 (0.332) germplasm at 45 DAS whereas highest value of copper was observed in G-68 (0.241) followed by G-33 (0.237) and G-51 (0.228) genotype at harvest stage.

Manganese - The Manganese content in Rice bean plants varied from 0.98 to 2.94 ppm at 45 DAS and 0.568 to 2.39 ppm at harvest. Maximum value of Mn content recorded in G-68 (2.94) followed by G-2 (2.48) and G-54 (2.42) germplasms at 45 DAS The highest value of manganese observed in G-68 (2.39) followed by G-69 (1.58) then G-33 (1.43) at harvest stage.

Iron - Iron content in plants varies from 13.51 to 47.43 ppm at 45 DAS and 10.16 to 30.92 ppm at harvest. Maximum value of Fe content recorded in G-68 (47.43) followed by G-7 (45.94) then G-38 (45.81) at 45 DAS whereas highest value observed in G-68 (30.92) followed by G-69 (27.45) then G-33 (27.41) at harvest stage.

Zinc - Zinc content in plants varies from 0.273 to 0.723 ppm at 45 DAS and 0.518 to 1.62 ppm at harvest. Maximum value of Zn content recorded in G-68 (0.723) followed by G-33 (0.678) then G-34 (0.653) at 45 DAS whereas highest value observed in G-68 (1.62) followed by G-7 (1.60) then G-51 (1.37) at harvest stage.

4.7 (b) Assimilation of secondary nutrients by germplasm at different stage

Sl. No.	Germplasms	Secondary nutrients (%)					
		At 45 DAS			At harvest		
		Calcium	Magnesium	Sulphur	Calcium	Magnesium	Sulphur
1	G-1	0.503	0.191	0.044	0.121	0.048	0.038
2	G-2	0.283	0.116	0.041	0.04	0.016	0.035
3	G-3	0.521	0.167	0.027	0.11	0.043	0.041
4	G-4	0.318	0.118	0.022	0.04	0.016	0.044
5	G-5	0.373	0.149	0.029	0.054	0.022	0.041
6	G-6	0.488	0.2	0.036	0.033	0.013	0.039
7	G-7	0.46	0.161	0.043	0.201	0.076	0.058
8	G-8	0.381	0.164	0.025	0.093	0.041	0.039
9	G-17	0.395	0.174	0.021	0.058	0.024	0.041
10	G-18	0.408	0.096	0.018	0.051	0.021	0.043
11	G-19	0.439	0.158	0.024	0.045	0.018	0.037
12	G-20	0.508	0.203	0.031	0.105	0.042	0.045
13	G-21	0.448	0.188	0.017	0.109	0.04	0.047
14	G-22	0.327	0.147	0.033	0.129	0.048	0.04
15	G-23	0.347	0.149	0.034	0.11	0.049	0.045
16	G-24	0.368	0.121	0.019	0.131	0.056	0.05
17	G-33	0.391	0.145	0.023	0.24	0.098	0.059
18	G-34	0.465	0.181	0.031	0.087	0.034	0.044
19	G-35	0.403	0.177	0.027	0.125	0.053	0.053
20	G-36	0.455	0.209	0.03	0.082	0.036	0.047
21	G-37	0.271	0.147	0.036	0.087	0.031	0.049
22	G-38	0.358	0.161	0.037	0.089	0.034	0.051
23	G-39	0.296	0.121	0.033	0.031	0.013	0.04
24	G-40	0.247	0.092	0.015	0.03	0.012	0.034
25	G-49	0.416	0.146	0.017	0.177	0.071	0.068
26	G-50	0.256	0.097	0.02	0.061	0.024	0.043
27	G-51	0.53	0.204	0.028	0.255	0.102	0.071
28	G-52	0.536	0.188	0.021	0.132	0.054	0.055
29	G-53	0.278	0.106	0.019	0.079	0.032	0.053
30	G-54	0.561	0.252	0.031	0.044	0.018	0.046
31	G-55	0.426	0.153	0.018	0.064	0.025	0.047
32	G-56	0.514	0.164	0.023	0.06	0.022	0.045
33	G-65	0.307	0.126	0.016	0.137	0.057	0.057
34	G-66	0.34	0.122	0.022	0.151	0.065	0.064
35	G-67	0.483	0.208	0.018	0.11	0.041	0.057
36	G-68	0.593	0.255	0.05	0.263	0.11	0.078
37	G-69	0.474	0.19	0.027	0.042	0.016	0.044
38	G-70	0.495	0.168	0.036	0.142	0.053	0.065
39	G-71	0.385	0.162	0.022	0.06	0.021	0.044
40	G-72	0.471	0.207	0.03	0.068	0.027	0.045
Mean		0.409	0.16	0.027	0.099	0.04	0.049
Range		0.247-0.593	0.092-0.255	0.015-0.050	0.030-0.263	0.012-0.110	0.034-0.078
S Em±		0.0082	0.0031	0.0004	0.0017	0.0006	0.0007
CD (P=0.05)		0.0254	0.0096	0.0013	0.0052	0.002	0.0022

4.8 Assimilation of micronutrients by germplasm at different stage

Sl. No.	Germplasms	Micronutrients contents (ppm)							
		At 45 DAS				At harvest			
		Cu	Mn	Fe	Zn	Cu	Mn	Fe	Zn
1	G-1	0.197	1.83	28.44	0.48	0.168	1.14	20.64	0.975
2	G-2	0.337	2.48	28.12	0.623	0.125	1.04	18.38	0.881
3	G-3	0.186	1.75	26.83	0.52	0.163	0.76	18.55	0.936
4	G-4	0.136	1.08	17.16	0.542	0.127	1.13	18.8	0.885
5	G-5	0.244	2.3	35.92	0.55	0.124	0.78	15.44	0.93
6	G-6	0.138	1.37	21.68	0.37	0.143	1.02	16.1	0.861
7	G-7	0.313	1.12	45.94	0.614	0.213	1.25	24.51	1.604
8	G-8	0.124	1.17	14.31	0.327	0.153	0.92	13.17	0.869
9	G-17	0.186	1.7	25.55	0.511	0.14	1.23	16.47	0.949
10	G-18	0.215	1.68	26.23	0.437	0.135	0.59	13.27	0.752
11	G-19	0.168	1.63	28.18	0.538	0.138	0.99	15.57	0.781
12	G-20	0.293	2.17	28.71	0.495	0.17	1.13	19.51	0.717
13	G-21	0.267	1.45	20.3	0.584	0.176	1.39	21.98	0.776
14	G-22	0.22	2.23	26.7	0.566	0.155	0.79	17.52	0.855
15	G-23	0.226	1.6	26.51	0.513	0.163	0.9	14.57	0.768
16	G-24	0.398	2.35	38.91	0.298	0.181	1.13	23.52	0.835
17	G-33	0.256	2.34	32.51	0.678	0.237	1.43	27.41	1.347
18	G-34	0.233	2.48	14.79	0.653	0.156	0.92	15.21	0.543
19	G-35	0.174	1.93	22.22	0.59	0.168	0.86	21.66	0.688
20	G-36	0.274	1.78	27.54	0.608	0.153	0.95	14.23	0.71
21	G-37	0.323	2.62	41.27	0.591	0.158	1.35	18.27	0.882
22	G-38	0.138	2.71	45.81	0.648	0.145	0.73	20.52	0.783
23	G-39	0.332	1.74	31.94	0.582	0.133	0.98	16.53	0.89
24	G-40	0.105	0.98	13.51	0.273	0.123	0.57	10.16	0.518
25	G-49	0.235	1.13	18.22	0.319	0.211	1.18	22.92	1.153
26	G-50	0.192	1.78	26.75	0.438	0.14	0.73	16.61	0.625
27	G-51	0.154	1.47	21.18	0.462	0.228	0.85	14.56	1.374
28	G-52	0.157	1.41	22.84	0.364	0.171	1.21	16.15	0.926
29	G-53	0.282	1.85	28.59	0.567	0.162	0.89	14.8	0.719
30	G-54	0.271	2.42	33.88	0.535	0.134	0.93	13.61	0.678
31	G-55	0.231	2.13	26.89	0.524	0.144	1.04	20.16	0.648
32	G-56	0.193	1.41	20.19	0.513	0.138	1.13	17.32	0.747
33	G-65	0.116	1.02	15.6	0.282	0.177	1.27	16.75	0.917
34	G-66	0.161	1.09	17.65	0.314	0.189	1.31	22.12	0.945
35	G-67	0.193	1.34	21.75	0.432	0.139	0.95	17.64	0.742
36	G-68	0.41	2.94	47.43	0.723	0.241	2.39	30.92	1.618
37	G-69	0.216	1.54	22.17	0.471	0.143	1.58	27.45	0.699
38	G-70	0.241	1.78	21.17	0.648	0.187	1.17	17.12	0.983
39	G-71	0.136	1.46	26.4	0.38	0.128	0.91	15.87	0.795
40	G-72	0.165	1.63	20.51	0.547	0.149	1.08	14.28	0.827
Mean		0.221	1.77	26.51	0.503	0.161	1.07	18.26	0.878
Range		0.105-0.41	0.98-2.94	13.51-47.43	0.273-0723	0.123-0.241	0.568-2.39	10.16-30.92	0.518-1.62
SEm±		0.004	0.029	0.482	0.008	0.029	0.183	3.26	0.145
CD $_{(P=0.005)}$		0.011	0.09	1.48	0.025	0.09	0.565	10.04	0.448

4.9 Nutrient uptake by different Germplasm

4.9 (a). Nitrogen uptake (kg ha^{-1})

The nitrogen uptake of rice bean by different germplasms is presented in Table 4.9. Perusal of the data revealed marked variation in nitrogen uptake among all the genotypes during the crop growth, Genotype (G-68) recorded significantly superior nitrogen uptake (99.48 kg ha^{-1}) over rest of genotypes. The minimum nitrogen uptake was recorded (35.56) in G-69 having mean value 69.01 kg/ha. All 40 germplams divided into 3 categories low (35-56 kg ha^{-1}),medium (56-77kg ha^{-1}) and high(>77 kg ha^{-1}) based on their nitrogen uptake.G-68 ,G-19 ,G-54 ,G-5 ,G-6 ,G-71 ,G-56 ,G-72 ,G-17 ,G-40 ,G-2 , G-18 ,G-37 ,G-4,G-38 (in decreasing order) seems to utilizes highest amount of nitrogen, almost one third of varieties in uptake. The highest uptake is due to high corresponding to content.

4.9 (b). Phosphorus uptake

Phosphorus uptake of rice bean by different genotypes in Table revealed marked variation in phosphorus uptake by Rice bean. The genotype G-68 showed significantly superior value (13.54 kg ha^{-1}) over all the other genotypes , whereas the minimum phosphorus uptake was recorded (5.13 kg ha^{-1}) in G-33 with mean value 9.72 kg/ha.All 40 germplams divided into 3 categories low (5-8 kg ha^{-1}) ,medium (8-10kg ha^{-1}) and high (>10 kg ha^{-1}) based on their Phosphorus uptake.G-68 ,G-37 ,G-5 ,G-54 ,G-38 ,G-39 ,G-56 ,G-19 ,G-53 ,G-40 found 10 highest promising genotype among all.

4.9 (c) Potassium uptake

The potassium uptake significantly differed among all genotypes. The genotype G-68 recorded significantly higher potassium uptake (37.36 kg ha^{-1}), which was statistically superior over other genotypes. The minimum potassium uptake was recorded (5.13 kg ha^{-1}) in G-40 with mean value 26.06 kg/ha. Likewise nitrogen and phosphorus germplams divided into 3 categories low (14-21 kg ha^{-1}) ,medium (21-28 kg ha^{-1}) and high (>28 kg ha^{-1})

based on their Potassium uptake.G-68 ,G-6,G-2,G-39 ,G-71,G-19 ,G-4 ,G-72 ,G-53, G-40, were highest in potassium uptake.

4.9 (d) Calcium uptake

Calcium uptake of rice bean by different germplasms in table 4.9 had marked variation in Calcium uptake among all the genotypes during the crop growth year. Genotype G-49 recorded significantly higher Calcium uptake of (19.22 kg ha^{-1}) over rest of genotypes followed by G-7(19.17 kg ha^{-1}), G-21 (19.11 kg ha^{-1}). The minimum calcium uptake was recorded (8.62 kg ha^{-1}) in G-5, followed by G-6, G-39 (9.12) having mean value of 15.20 kg ha^{-1}

4.9.(e) Magnesium uptake

The data on magnesium uptake of ricebean was affected by different genotypes is presented in Table 4.9 revealed marked variation during the growth period. Analysis of data on Magnesium uptake indicated that G-49 showed significantly superior value (7.69 kg ha^{-1}) over all the other genotypes followed by G-23 (7.66 kg ha^{-1}) ,whereas the minimum Magnesium uptake was recorded (3.52 kg ha^{-1}) in G-6 followed by G-5 (3.54 kg ha^{-1}) then G-39 (3.74 kg ha^{-1}) with mean value 6.07 kg ha^{-1}.

4.9(f) Sulphur uptake

As regards sulphur uptake by ricebean as affected by different germplasm is presented in Table 4.9 showed significant variation among all genotypes. The genotype G-5 recorded significantly higher sulphur uptake (11.78 kg ha^{-1}), which was statistically superior to rest of the genotypes followed by G-39 (11.77 kg ha^{-1}) and by G-54 (11.53 kg ha^{-1}), whereas the minimum sulphur uptake was recorded (4.52 kg ha^{-1}) in G-33 with mean value 8.55 kg ha^{-1}.

4.10 Micronutrient uptake (kg ha^{-1})

The uptake of micronutrients by different genotype differed significantly .the maximum uptake of all the micronutrients were found by genotype G-39 having 0.039, 0.0295, 0.4879, and 0.0269 kg ha^{-1} by Cu, Mn, Fe, Zn respectively. However G-69 had lowest uptake of Cu, Mn, Fe and Zn having 0.0016, 0.0106, 0.1842 and 0.0100 kg ha^{-1} respectively. This indicate that the G-39 have maximum content and uptake of micronutrients.

4.9 Uptake of macronutrients By ricebean germplasms at harvest

Sl. No.	Germplasms	Macronutrients uptake (kg ha^{-1})					
		Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulphur
1	G-1	57.71	7.94	27.79	18.46	7.38	5.8
2	G-2	87.82	10.88	33.7	10.61	4.25	9.29
3	G-3	59.56	8.23	29.29	18.15	7.1	6.75
4	G-4	80.1	9.91	31.57	10.44	4.17	8.87
5	G-5	94.56	12.93	28.76	8.62	3.54	11.1
6	G-6	91.57	11.21	34.44	9.12	3.52	11.78
7	G-7	40.35	5.91	22.32	19.17	7.29	5.53
8	G-8	61.76	8.51	24.81	16.84	7.41	7.14
9	G-17	88.82	9.34	27.33	13.21	5.42	9.34
10	G-18	86.12	10.13	28.22	12.3	5.04	10.37
11	G-19	95.8	12.17	31.68	11.41	4.56	9.38
12	G-20	61.54	8.69	29.9	18.28	7.31	7.82
13	G-21	62.7	9.16	25.6	19.11	7.15	8.19
14	G-22	51.59	8.33	27.77	18.82	6.96	5.85
15	G-23	62.15	8.52	21.93	17.4	7.66	7.1
16	G-24	49.49	8.38	20.15	17.71	7.62	6.76
17	G-33	41.75	11.93	15.78	18.39	7.54	4.52
18	G-34	73.63	9.16	27.28	16.59	6.47	8.39
19	G-35	49.18	8.93	22.1	18.3	7.68	7.76
20	G-36	74.34	8.87	29.25	15.47	6.81	8.87
21	G-37	83.18	13.25	29.99	17.48	6.29	9.8
22	G-38	79.3	12.72	26.93	16.41	6.24	9.41
23	G-39	75.93	12.61	33.85	9.12	3.74	11.77
24	G-40	35.56	5.13	14.83	12.49	5.12	10.22
25	G-49	40.28	7.38	18.57	19.22	7.69	7.38
26	G-50	71.57	10.91	25.67	13.86	5.54	9.77
27	G-51	38.73	5.51	16.24	18.74	7.5	5.22
28	G-52	42.6	7.75	19.23	18.29	7.5	7.61
29	G-53	74.25	11.96	24.34	16.23	6.65	10.93
30	G-54	95.76	12.78	28.11	10.97	4.41	11.53
31	G-55	81.78	11.85	27.77	13.88	5.41	10.2
32	G-56	90.34	12.21	28.35	13.83	4.98	10.37
33	G-65	50.89	7.93	20.38	16.68	7	6.96
34	G-66	41.39	7.54	18.68	15.95	6.91	6.79
35	G-67	59.79	9.99	23.26	18.95	6.98	9.82
36	G-68	99.48	13.54	37.36	10.59	4.13	10.66
37	G-69	87.85	5.23	29.58	17.65	7.41	5.23
38	G-70	61.73	8.22	16.43	17.18	6.36	7.85
39	G-71	90.61	11.99	32.74	13.83	4.84	10.15
40	G-72	88.92	11.11	30.29	14.82	5.93	9.81
Mean		69.01	9.72	26.06	15.2	6.07	8.55
Range		35.56-99.48	5.13-13.54	14.83-37.36	8.62-19.22	3.52-7.69	4.52-11.78
S Em±		3.47	0.47	1.29	0.711	0.272	0.38
CD $_{(P=0.005)}$		10.7	1.44	3.96	2.19	0.838	1.18

4.10 Uptake of micronutrients by ricebean germplasms at harvest

Sl. No.	Germplasms	Micronutrients uptake (kg ha^{-1})			
		Cu	Mn	Fe	Zn
1	G-1	0.0026	0.0174	0.315	0.0149
2	G-2	0.0033	0.0276	0.4877	0.0234
3	G-3	0.0027	0.0126	0.3052	0.0154
4	G-4	0.0033	0.029	0.2652	0.0231
5	G-5	0.0036	0.0163	0.4438	0.0267
6	G-6	0.0034	0.0279	0.4401	0.0235
7	G-7	0.002	0.0119	0.2338	0.0153
8	G-8	0.0028	0.0167	0.2385	0.0157
9	G-17	0.0032	0.028	0.3751	0.0216
10	G-18	0.0033	0.0142	0.3201	0.0181
11	G-19	0.0035	0.0252	0.3946	0.0198
12	G-20	0.003	0.0196	0.3391	0.0125
13	G-21	0.0031	0.0242	0.3828	0.0135
14	G-22	0.0023	0.0115	0.256	0.0125
15	G-23	0.0026	0.0141	0.2299	0.0121
16	G-24	0.0024	0.0153	0.3181	0.0113
17	G-33	0.0018	0.011	0.21	0.0103
18	G-34	0.003	0.0176	0.2901	0.0104
19	G-35	0.0025	0.0126	0.3171	0.0101
20	G-36	0.0029	0.0179	0.2685	0.0134
21	G-37	0.0032	0.027	0.3653	0.0176
22	G-38	0.0027	0.0135	0.3784	0.0144
23	G-39	0.0039	0.0295	0.4865	0.0269
24	G-40	0.0033	0.0182	0.4368	0.0109
25	G-49	0.0023	0.0128	0.2489	0.0125
26	G-50	0.0032	0.0165	0.3773	0.0142
27	G-51	0.0017	0.0175	0.2273	0.0101
28	G-52	0.0024	0.0167	0.2234	0.0128
29	G-53	0.0033	0.0183	0.3052	0.0148
30	G-54	0.0034	0.0233	0.3412	0.017
31	G-55	0.0031	0.0226	0.4373	0.0141
32	G-56	0.0032	0.026	0.3992	0.0172
33	G-65	0.0022	0.0155	0.2044	0.0112
34	G-66	0.002	0.0139	0.2348	0.0162
35	G-67	0.0024	0.0163	0.304	0.0128
36	G-68	0.0036	0.0215	0.3673	0.0131
37	G-69	0.0016	0.0106	0.1842	0.01
38	G-70	0.0023	0.0141	0.2068	0.0119
39	G-71	0.003	0.0211	0.3659	0.0183
40	G-72	0.0032	0.0235	0.3112	0.018
Mean		0.0028	0.0187	0.3209	0.0154
Range		0.0016-0.0039	0.0106-0.0295	0.184 - 0.487	0.0100-0.0269
SEm±		0.0001	0.0007	0.0117	0.000006
CD $_{(P=0.05)}$		0.0003	0.002	0.0359	0.0002

4.11 Microbial population

Data pertaining to soil microbial population are presented in Table 4.11. Changes in microbial populations were statistically significant due to as an varietal effect all germplasms.

4.11.1 Total bacteria (cfu dry soil)

Total bacterial population in soil was observed to be reduced statistically from 45 DAS to At harvest stage. Maximum population was recorded in G-68 (56.45) followed by G-49 (52.86) 45 DAS stage while minimum counts were estimated in G- 40(31.76)

The mean population of total bacteria recorded to be 42.06 & 21.38 at 45 DAS and At harvest. At harvest stage of sampling maximum total soil bacterial population recorded in G- 68 (27.43) followed by G-69 (27.13) then by G-66 (26.73).lowest population recorded in G-40 (14.35).

4.11.2 Actinomycetes (cfu dry soil)

Soil actinomycetes population was also reduced significantly at harvest stage. Maximum population was recorded in G-68 (41.53) followed by G-67 (39.67) then by G-49 (38.21) 45 DAS stage while minimum counts were estimated in G-51 (20.11)

The mean population of total Actinomycetes recorded 28.23 & 15.88 at 45 DAS and At harvest. At harvest stage of sampling maximum population recorded in G-68 (26.42) followed by G- 65 (26.19),G- 67 (24.33). At harvest stage of sampling maximum total soil bacterial population recorded in G- 40 (10.97).

4.11.3 Fungi (cfu dry soil)

Soil fungi follow the similar trend as that of total soil bacterial population. It was noted maximum at 45 DAS stage. Maximum population was recorded in G-68 (29.42) followed by G-65 (29.19) then by G- 66 (25.93) 45 DAS stage while minimum counts were estimated in G- 22(13.97) mean values of fungi population are 18.88 at 45 DAS and 13.55 at harvest. At harvest stage of sampling maximum population recorded in G-68 (19.73) followed by G-67 (18.64),G-66 (17.46) while G-40(9.93) observed minimum population.

4.11 Effect of different germplasms on microbial Population (cfu /gm dry Soil) in experimental soil

S. No.	Germplasms	At 45 DAS			At harvest		
		TBC (CFU x 10^{-5})	Actinomycetes (CFU x 10^{-2})	Fungi (CFU x 10^{-3})	TBC (CFU x 10^{-5})	Actinomycetes (CFU x 10^{-2})	Fungi (CFU x 10^{-3})
1	G-1	37.56	33.37	22.65	25.15	19.65	15.18
2	G-2	40.8	31.34	17.31	21.56	14.31	13.45
3	G-3	36.15	24.73	16.37	17.45	13.37	11.36
4	G-4	44.13	32.58	18.54	22.83	15.54	15.13
5	G-5	48.65	37.15	15.17	19.45	12.17	10.91
6	G-6	41.87	27.43	15.45	23.56	12.45	11.32
7	G-7	40.32	26.71	16.36	20.25	13.36	12.22
8	G-8	44.74	33.75	19.37	26.9	16.37	14.65
9	G-17	43.53	31.91	17.76	18.76	14.76	12.88
10	G-18	45.45	34.88	15.75	15.67	12.75	12.23
11	G-19	35.76	24.31	16.37	16.73	13.37	12.65
12	G-20	36.55	25.11	18.15	23.45	15.15	13.28
13	G-21	36.4	24.52	15.18	18.12	12.18	12.15
14	G-22	32.56	22.31	15.75	16.37	12.75	13.18
15	G-23	39.22	25.61	15.27	20.97	12.27	12.18
16	G-24	39.48	26.21	17.37	21.57	14.37	13.65
17	G-33	41.67	28.33	19.37	22.71	16.37	15.28
18	G-34	50.46	37.21	24.87	25.45	21.87	16.41
19	G-35	43.55	32.11	21.77	24.93	18.77	15.73
20	G-36	38.43	25.83	16.73	19.73	13.73	11.97
21	G-37	34.87	34.12	15.38	15.84	12.38	10.75
22	G-38	40.87	31.11	18.54	21.76	15.54	13.65
23	G-39	35.98	24.14	17.63	15.3	14.63	14.62
24	G-40	31.76	20.11	13.97	14.35	10.97	9.93
25	G-49	52.86	38.21	23.97	23.76	20.97	15.37
26	G-50	37.26	24.12	17.38	16.4	14.38	10.85
27	G-51	34.78	22.23	16.76	24.87	13.76	11.63
28	G-52	33.76	22.21	14.87	20.87	11.87	11.55
29	G-53	42.85	31.42	20.63	22.37	17.63	12.85
30	G-54	47.13	33.85	21.51	22.76	18.51	14.56
31	G-55	36.55	25.23	16.37	17.83	13.37	12.65
32	G-56	36.43	32.14	15.81	20.64	12.81	11.82
33	G-65	52.56	37.76	29.19	24.5	26.19	15.76
34	G-66	49.75	36.27	25.93	26.73	22.93	17.46
35	G-67	54.63	39.67	27.33	24.73	24.33	18.64
36	G-68	56.45	41.53	29.42	27.43	26.42	19.73
37	G-69	38.45	26.31	18.65	27.13	15.65	13.65
38	G-70	34.5	21.78	15.2	24.19	12.2	12.11
39	G-71	36.18	24.15	23.37	21.37	20.37	16.35
40	G-72	45.6	31.71	17.83	20.84	14.83	12.27
Mean		42.06	28.23	18.88	21.38	15.88	13.55
Range		31.76-56.45	20.11-41.53	13.97-29.42	14.35-27.43	10.97-26.42	9.93-19.73
SEm±		3.39	2.33	1.7	1.54	1.21	1.13
CD $_{(P=0.005)}$		10.43	7.17	5.25	4.75	3.72	3.48

4.12 Nitrogen build up in soil by rice bean germplasms -(kg ha^{-1})

Data on nitrogen build up in soil by Rice bean germplasms presented in table 4.12 , germplasms improve the N status in soil G-68 (152.66), G-5 (124.71),G-2 (92.88),G-33 (122.68),G-34 (128.87),G-8 (117.00),G-1(87.86),G-4 (97.71), G-53 (91.86),G-54 (125.91), G-56 (70.34), G-70 (91.88), G-72 (81.44) showed appreciable amount of N fixation in soil by nodules.

4.12 Nitrogen build up in soil by rice bean germplasms-(kg ha $^{-1}$)

S.NO.	Germplasms	Nitrogen fixation (kg/ha)	S.NO.	Germplasms	Nitrogen fixation (kg/ha)
1	G-1	87.86	21	G-37	38.07
2	G-2	92.88	22	G-38	59.3
3	G-3	27.02	23	G-39	29.28
4	G-4	97.71	24	G-40	19.05
5	G-5	124.71	25	G-49	70.43
6	G-6	71.57	26	G-50	26.46
7	G-7	57.96	27	G-51	68.88
8	G-8	117	28	G-52	35.12
9	G-17	81.34	29	G-53	91.86
10	G-18	66.12	30	G-54	125.91
11	G-19	25.6	31	G-55	42.7
12	G-20	41.54	32	G-56	70.34
13	G-21	30.15	33	G-65	106.13
14	G-22	24.12	34	G-66	121.72
15	G-23	55.27	35	G-67	68.45
16	G-24	42.01	36	G-68	152.66
17	G-33	122.08	37	G-69	141.02
18	G-34	128.87	38	G-70	91.88
19	G-35	79.33	39	G-71	70.61
20	G-36	41.77	40	G-72	81.44
21	G-37	38.07	MEAN	73.76	
22	G-38	59.3	RANGE	19.05-152.66	

DISCUSSION

The present investigation was a component of Technical programme of ongoing All India Coordinated Research Project on Forage crop at JNKVV Jabalpur. The experiment on Black soil was conducted for "Screening of Rice bean Germplasm for their growth quality and nitrogen fixing efficiency˝ was carried out during kharif 2011. Forty Rice bean germplasm were screened for testing their efficiency under field condition, to shortlist more promising for their growth attributing character's, nodulation, nutrient uptake, fodder yield and their quality. The objective mainly enucleated the selection of best suited genotype of rice bean having high nitrogen fixing capacity and their contribution in building soil microbial populations.

The discussion is based on the results of experimental findings.

5.1 Morphological characters and fodder yield of Germplasms

The plant height of different genotypes does vary because of its genetic characteristics. The observation were recorded at two stages being one at 45 Days after sowing and at harvest of Rice bean as fodder. among many cultivar the height increase was recorded having range from 7.80 to 25.33 cm with the mean value of 14.33 cm. it is observed that sometimes a variety may not attain normal height, may not pickup growth,but as soon as the congenial environment for the growth of microorganisms starts the process of mineralization starts and the translocation of all the mineral nutrients made available to the plants which picks up fast growth . The variety G-68 observed to attain maximum plant height followed by G-3,G-19 having 95.33 and 93.44 cm. This result was similar to the results reported by Dwivedi (1997) reported that at normal agriculture practices Rice bean plants height increases with advancement of growth stages. Katoch (2011) also found that there is significant difference in plant height of Rice bean observed at 115 DAS. This may be attributed to better translocation of mineral matters for the rapid elongation due to nitrogen concentration in the form of protein, amino acids in the growing tissues.

Dry matter of the Rice bean plant of various genotypes differed significantly at 45 DAS and at harvest stage. The dry weight of genotype varied from 0.57 to 2.03 and 18.63 to 75.42 g/plant at 45 DAS and at harvest with a mean value of 1.05 and 49.45 gm/plant respectively .the maximum dry matter of Rice bean was recorded in G-68 cultivar and lowest by G-40 cultivar.

The moisture is the important component of plant, It is observed that moisture increases with growth stages and become least at the harvest stage of crop .In case of Rice bean which is harvested as fodder at about 90 days, The moisture content varied with germplasm having ranged from 78.2 to 95.41 percent at harvest with mean value of 86.6 and 80.12 percent at 45 DAS and at harvest respectively. If the rice bean harvested at 90 DAS as fodder the moisture depletion recorded only by 6.5 percent.

Significant variation in fodder yield is obvious to vary from genotypes; It is observed that at this stage the most productive genotype yields maximum and performs better then some of the other germplasm. Maximum fodder yield was recorded by G-68 (294.33 q/ha) Similar results have been reported by Praveen *et al.* (2001). Ooman and Sumabai (2002) stating that Rice bean as a fodder has high fodder production potential up to 35 t ha^{-1} and show positive correlation with dry matter content ,has been also confirmed by Manohar and Bhattacharya (2005).

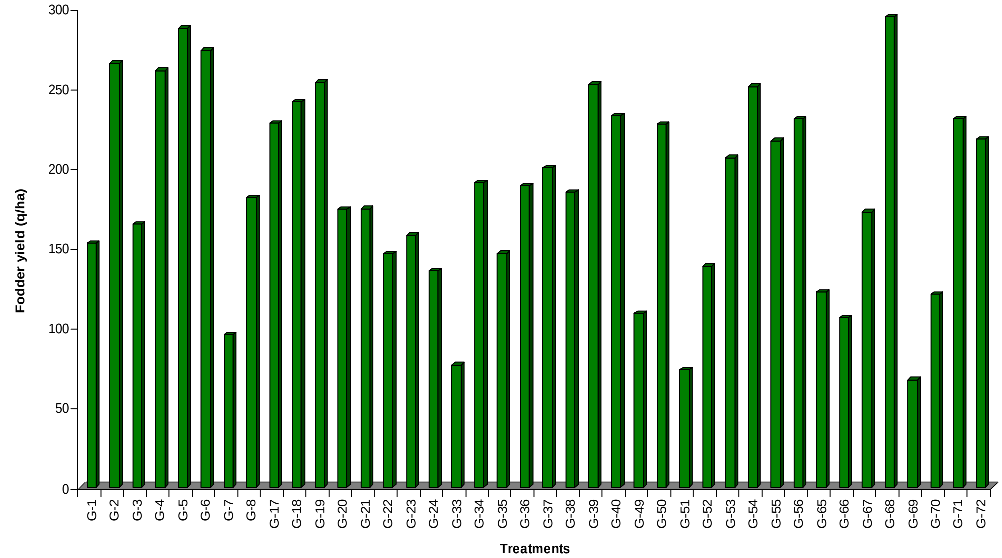

Fig 1 : Fodder yield of rice bean germplasm

5.2 Nodulation

The nodulation process in different bean crops starts within 2-3 weeks ,In winged bean nodulation commences two weeks after sowing ,after three weeks the nodules begins to reach their bacteroid stage and by week four ,fully develop nodules are formed, reports Iruthayathas and Herath (1981).

In the present investigation nodulation ranged from 4.33 to 181.87 having mean number of 90.85 nodules .G-68 recorded maximum number of nodule. Such variation has been also reported by Okereke and Unegbu (1992) ,for common bean over 600 cultivars were tested for this phenomenon (Graham and Roses 1977 ,Graham and Tample 1984).

An attempt was also made to study the crude protein content in Rice bean which ranged from 6.29-21.17 percent due to various germplasm. Chandel *et al.* (1978) also reported that ricebean protein content varying between 14-21 percent which confirms the present experimental results of the germplasms.

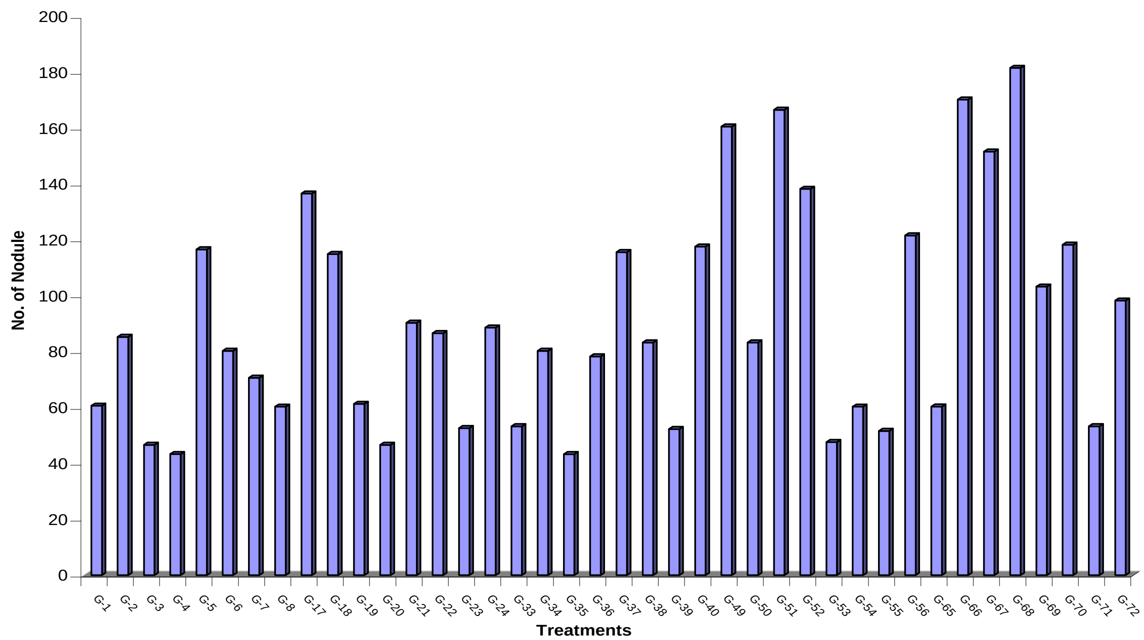

Fig.2 : EFFECT OF DIFFERENT GERMPLASMS ON NODULATION

5.3 Soil Nutrient Status buildup due to Genotypes

The amount of nutrient left in the soil depends on various factors especially the type of fertilizer used, type of crop grown .The Rice bean being a legume crop have the capacity to fix elemental nitrogen.The NPK applied to plant through fertilizers are not fully utilized ,it undergoes losses also ,similar results have been also reported by Singh and Singh (1982).

During the growth of Rice bean the pH did not varies significantly due to germplasm. There was slight decrease in the pH at harvest as compared to initial status .Li et al .(2004) reported that legumes such as alfa alfa,chickpea lupins and cowpea can release considerable amount of organic anions which sometimes lower Rhizosphere pH .similarly Tang *et al.(*1997 c) reported that nitrogen fixing plants absorbs more cations the anions creating net efflux of H^+ into the rhizosphere..

The electrical conductivity also differed significantly with genotypes having value ranged from 0.369 to 0.385 dsm^{-1}. The rice bean germplasm increase the organic carbon content at harvest stage .Pathak (2003) reported increase of organic matter in soil about 20-30 percent of total living biomass of trees in the roots ,Through decayed roots improving the organic matter .

The available nitrogen status of soil was observed to improve, similar results have been also reported by Dubey an Shrivastava (1991) ,Shahandah *et. al*.(2004) and Emmanuel and Francis (2010). Status of P K reduced also reported by Qasim *et al.* (1994).Suggesting that legume increases soil organic matter decreases available P,K and soil pH in soybean ,pigeon pea and rice bean .Significant variation observed in S, Ca and Mg content at harvest.

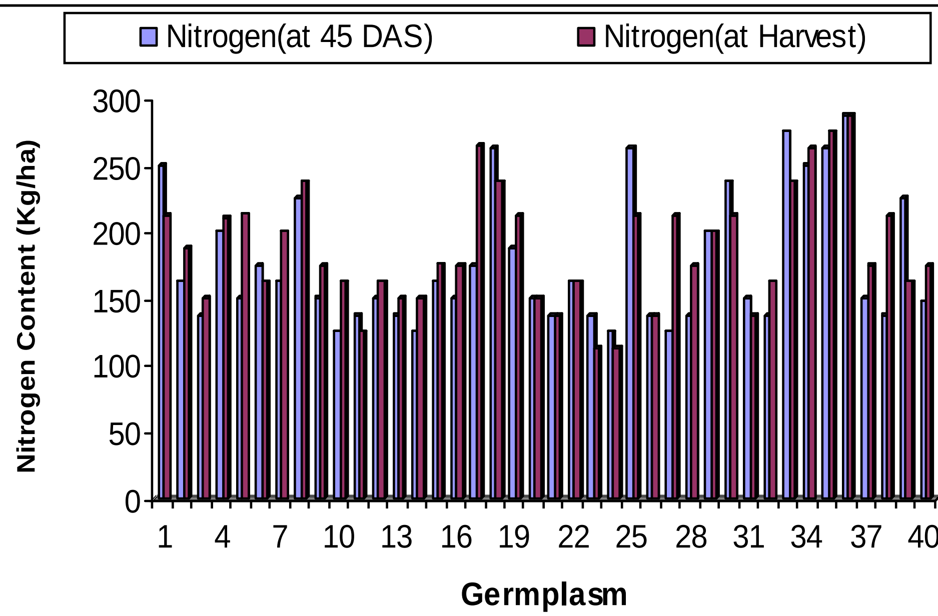

Fig.3: Nitrogen content in soil (Kg h^{-1})

5.4 Variation in nutrient content of various Germplasms

Forty genotypes were tested for selecting the most potential one for fodder productions and their nutrient content. The macro and micronutrient were estimated in all the genotypes at 45 DAS and at harvest to select the best germplasm .The N,P,K ,Ca, Mg, S ,Cu, Fe, and Zn content increase significantly among germplams at 45 DAS ,but the corresponding values of content decreased as the as the growth advanced towards maturity .Significant decrease was observed in N P K content in cowpea ,potassium accumulation was high and decline with crop age .Gumbs *et al.(*1982).

Different genotype had variable phosphorus content in plant, which ranged from 0.028-0.76 percent at harvest .genotype G-68 recorded maximum phosphorus content in plant which ranged from 0.038-0.078 percent in plant at harvest. Genotype G-68 recorded maximum phosphorus content ranging 0.076 and 0.078 percent at 45 DAS and at harvest respectively. The N P K content have been also observed to have assimilated by G-68 significantly over most of the germlasms .Ca, Mg and sulphur content were also varied significantly as compared to the rest of the germplsms .Saharan *et al.(*2000) confirms the results.

Every variety has capability to assimilate nutrient of its demand .Higher yield have greater demand on all nutrients, thus the macro and micro nutrient will assume greater importance. .Plant species varieties differ in their requirement of nutrient .The micronutrient assimilation by different genotype differ significantly in their content. Mean content of Cu, Mn and Fe were 0.221, 1.77 and 26.51 at 45 DAS and 0.161, 1.07 and 18.26 ppm were recorded at harvest respectively. It is observed that the content decreased at the harvest stage. This may be attributed to the microbial activity changing the chemical composition as the plant matures. Norton and Poppi (1995),as the forage crop matures the accumulates of structural cell wall dilutes . The metabolic pools as represented by cell contents have been reported by Van soest (1994).

5.5 uptake of different nutrient by the genotypes tested

Uptake is the product of percent nutrient content and the dry matter production of the crop. It is observed that the uptake was also similar to the high dry matter production and nutrient content in the sample differed significantly with respect to germplasm. N, P, K, Ca, Mg and S uptake in rice bean,G-68 show maximum Ca ,Mg uptake while G-40 and other observed to be minimum attributing to be its corresponding yield has been also reported by Westerman (2011). having mean uptake of 15.20,6.07 and 8.55 kg ha^{-1} of Ca ,Mg and sulphur respectively.

Supply and uptake of micronutrient is a complex process and probably several plant and soil factors are involved Zende (1987).The uptake of copper ,Manganese and Iron have increase with the yield and content in the sample.G-68,G-4,G-2 and G-5 genotypes have

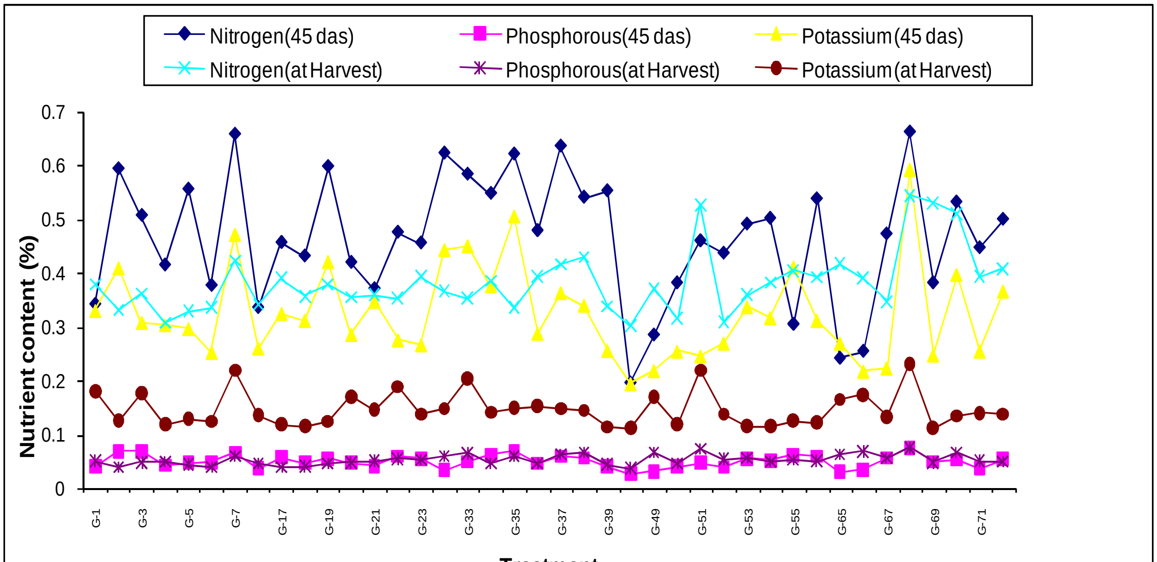

Fig 4: Assimilation of NPK in rice bean germplasm at 45 DAS and at harvest

recorded maximum uptake as they recorded higher fodder yield ,has been also reported by Bharadwaj et al.(1984).

Plant species and varieties differ in their nutrient requirement Ca and Mg from the soil solution is supplied to plant roots by mass flow and diffusion. In the present investigation Mg uptake was less than Ca or K .The change in organic matter content will drastically reduce the quantity of N mineralization and thus soil N availability to crops.

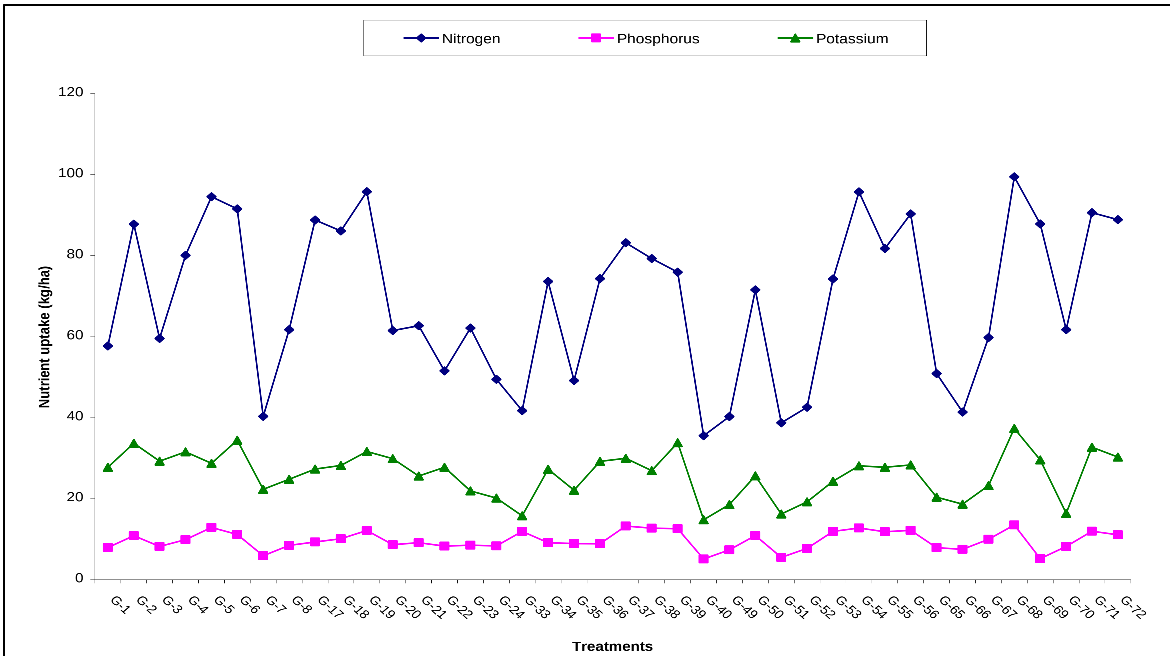

Fig. 5 : NPK uptake by rice bean gernplasm

5.6 Microbial status

Microbial population or activity can precede detectable changes in soil physico-chemical properties by providing early signs of soil improvement (Pankhurust *et al.* 1995)

The population of bacteria, fungi, and actinomycetes maximum at 45 DAS and declined at harvest stage in comparison of initial status. According to Reichard *et. al*.(2001) irrespective of the water regime ,total bacterial cell counts declined towards the end of the cropping period.

In the soil profile, soil bacterial population are predominant followed by actinomycetes and fungi Venkateswarlu *et al.* (2004).

Among all the germplasm it was reported that the population of microbes increased with increasing rate of nitrogen. These results are also supported by Dong *et al*.(2008).

5.7 Biological nitrogen fixation

Appreciable nitrogen fixation recorded in G-68 (152.66), G-5 (124.71),G-2 (92.88),G-33 (122.68),G-34 (128.87),G-8 (117.00),G-1(87.86),G-4 (97.71), G-53 (91.86),G-54 (125.91), G-56 (70.34), G-70 (91.88), G-72 (81.44).The literature report values of symbiotically fixed nitrogen under field condition ranges from 15-648 kg N/ha (Schwanke *et al.* 1998) and (Sprent *et. al.* 1977).have also reported similar result.

Hadarson *et al.* (1993) investigate the nitrogen fixation potential of various cultivar of common bean. They reported that nitrogen fixation ranges from 25 – 165 kg/ha. The germplasm having high nitrogen fixing capacities also show high nodulation.Li *et al.*(1993) suggested that the number of effective nodule, the effective dry weight could use as parameter to evaluate nodulation nitrogen fixation abilities.

There are number of rhizobium species exist but a specific host legume is required for nitrogen fixation. Seed inoculation with correct inoculants is the best if carefully match to cultivars and strain of inoculation.

The nodule present on the legume roots necessarily does not indicates nitrogen fixation by active rhizobia. Large elongated pink to red colour, the leghaemoglobin nodule cell containing rhizobia are capable of fixing nitrogen.(Tisdale *et. al.* 1995)

The legume roots may excrete small amount of amino acid and other organic N compound by microbial decomposition of root nodules tissue contribute nitrogen.

That's why the selection of legume varieties which are capable of fixing nitrogen is needed. Soil temperature, soil moisture and climate controls the N mineralization by soil microbes.

Soil reaction is one of the important factor restricting the survival and growth of micro-organisms rhizobia in soil effecting nodulation .in the present investigation the soil pH and EC were quite normal and helped forming effective nodules.

The initiation and development of nodules also effected copper ,Iron and other elements. Excess NO^{-}_{3} concentration in soil reduces nitrogenase activity, nodule losses pink colour affect N fixation.

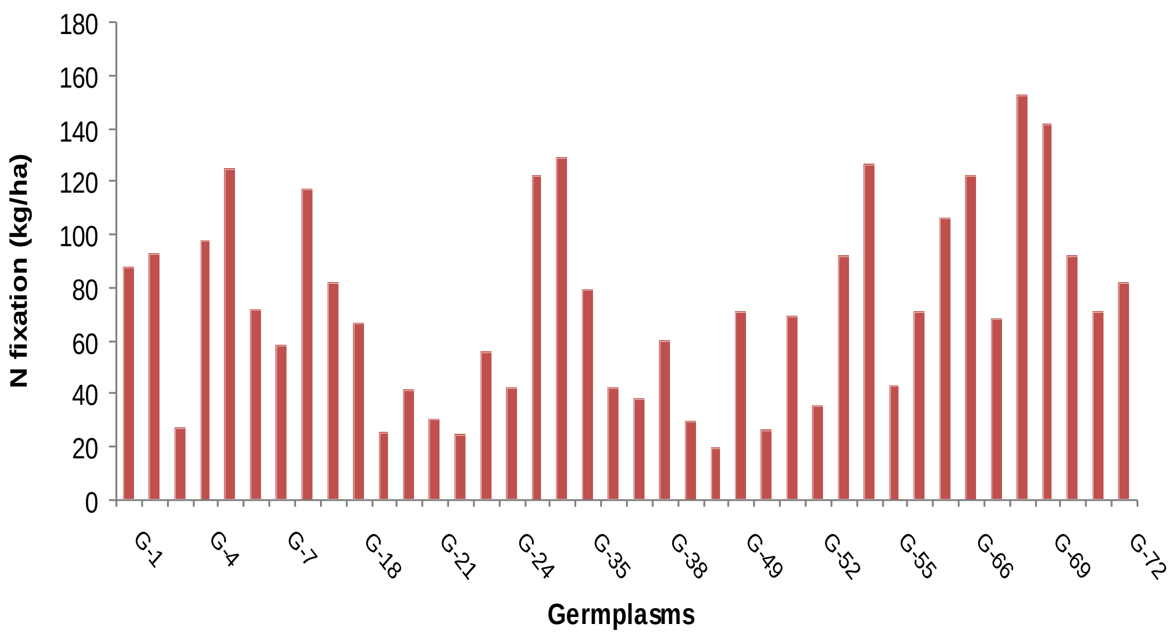

Fig. 7: Nitrogen Fixation by Germplasms (kg/ha)

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

The present investigation was a component of technical programme of AICRP on forage crop JNKVV Jabalpur and was accomplished during *Kharif* 2011, taking forty different germplasms of Rice bean.

The crop was grown with good agriculture practice for "Screening of Ricebean germplasm lines, for their Growth ,Quality and Nitrogen fixing efficiency ."with objective to separate most suitable variety of rice bean for higher fodder yield with good amount of protein.

The genotype influence on various parameters at different physiological stages of rice bean was recorded and the results were interfaced.

The experiment was undertaken at typic Haplustert soil on the field of fodder research form with forty different germplasm in randomized block design replicating three times followed under optimum agronomic practices.

Keeping on view the objective of the investigation the observation were recorded and the data are presented statically on various parameters for establishing the scientific interpretation.

The various parameters recorded such as Plant height, Root nodulation, fodder yield, nutrient buildup and nitrogen fixed in soil have been recorded.

It was observed that that the different genotype varied significantly at 45 DAS and at harvest .Among forty germplasm the best ten of them were selected regarding their influence the fodder yield, nutrient content, Protein content and other component.

Table 6.1 Characters of selected Genotypes

Germ.	Fodder yield (q/ha)	Nodule number	Nitrogen content in plant (%)	Phoaph orus content in plant (%)	Potassi um content in plant (%)	N build up in soil (kg/ha)	Protein content in straw (%)
G-2	265.32	85.33	0.331	0.041	0.127	92.88	2.069
G-5	287.41	116.67	0.329	0.045	0.130	124.71	2.056
G-6	273.33	80.33	0.335	0.041	0.234	71.57	2.094
G-4	260.92	43.36	0.307	0.038	0.121	97.71	1.919
G-18	241.33	115.0	0.312	0.042	0.117	66.12	1.950
G-19	253.45	61.33	0.378	0.048	0.125	25.60	2.363
G-40	232.34	117.67	0.195	0.021	0.113	24.12	1.219
G-39	252.00	52.33	0.338	0.046	0.115	29.28	2.113
G-68	294.33	181.67	0.545	0.050	0.074	152.66	3.406
G-20	173.83	46.67	0.354	0.050	0.172	41.54	2.213

As regard the nutrient content at different growth stages, some of the germplasm has perform very good and differed significantly superior compared to other germplasm under testing.

The nutrient content gradually decreased as the growth advanced to maturity from 45 DAS to the harvest of rice bean as fodder,N,P,K content were 0.467,0.051 0.325 and 0.383,0.055,0.149 respectively.

The protein content ranged from 6.29-21.17 % in nodules. Overall it was observed and recorded with respect to processed data statistically the genotype G-68 best which can be selected for further studies.

Conclusion

It can be well concluded that among various genotype selected for investigation has performed well. The yield, nutrient content, nodule formation nutrient uptake etc. has been recorded in G-68,From the point of view of breeding characteristic such as root elongation, nodule formation, nutrient assimilation and fodder yield was found better, this genotype can be utilized in the improvement work of rice bean.

Suggestion for future work

There is need to take up comprehensive research on the effect of graded doses of fertilizer with incorporation of organics under IPNS ,on the quality of the produce such as amino acid, fats, vitamins and enhancing protein and nutrient build up .

Adaptive trials can be taken for the verification of Integrated Plant Management System supported by training in good agriculture management practice for efficient use of genotype respectively.

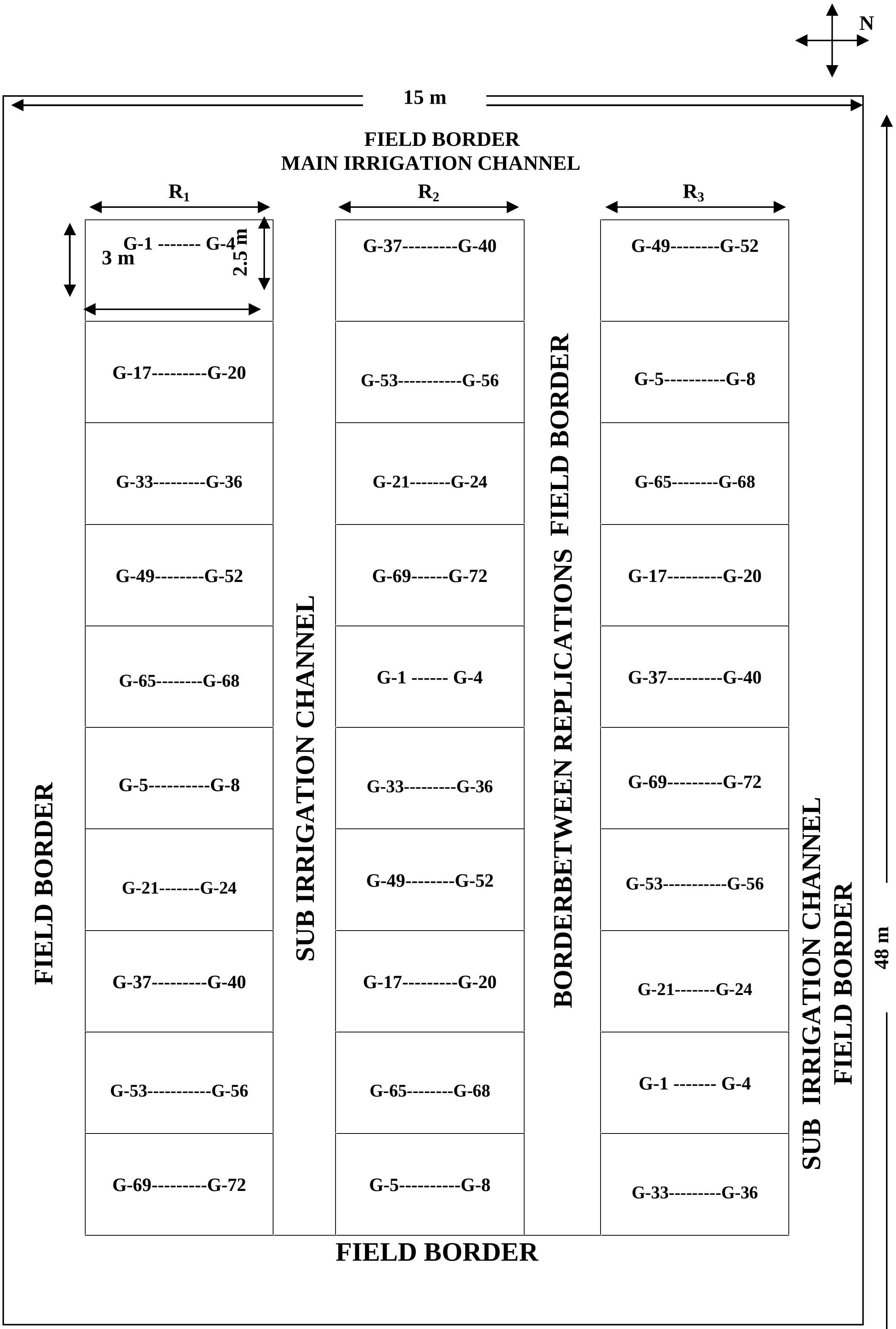

Fig. 3.2: LAYOUT PLAN OF THE EXPERIMENTAL FIELD.

Gross plot size	3 × 4 m	Field Border	1.25 m
Net plot size	2.5 × 3.5 m	Main irrigation channel	1.0 m
Plot Border	1.0 m	Sub irrigation channel	0.5 m
		Main irrigation channel	1. 0 m

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ABSTRACT

Title of the thesis	:	**"Screening of Ricebean germplasm lines, for their Growth, Quality and Nitrogen fixing efficiency."**
Student's Name	:	**Swati Tiwari**
Permanent address		**D/o Shri R.S. Tiwari** **Rudri colony,Q.no. G-31,Dhamtari (C.G.)**
Name and address of major advisor	:	**Dr. B.Sacchidanand,** (**Principal Scientist),** **Department of Soil Science and Agril. Chemistry,** **JNKVV, Jabalpur.**
Degree to be awarded	:	**Master of Science in Agriculture**
Year of award of degree	:	**2012**
Major subject	:	**Soil Science and Agricultural Chemistry**
Total no. of pages in the thesis	:	**87**
Number of words in the abstract	:	**360**

Signature of Advisor	Signature of Head of Department	Signature of Student
(Dr. B. Sacchidanand)	**(Dr. A.K. Rawat)**	**(Swati Tiwari)**

ABSTRACT

The present investigation was a component of technical programme of AICRP on forage crop JNKVV Jabalpur and was accomplished during *Kharif* 2011, taking forty different germplasms of Rice bean.

The crop was grown with good agriculture practice for "Screening of Ricebean germplasm lines, for their Growth ,Quality and Nitrogen fixing efficiency ."with objective to separate most suitable variety of rice bean for higher fodder yield lash with ample amount of protein.

The genotype influence on various parameters at different physiological stages of rice bean was recorded and the results were interfaced.

The experiment was undertaken at typic Haplustert soil on the field of fodder research form with forty different germplasm in randomized block design replicating three times followed under optimum agronomic practices.

Keeping on view the objective of the investigation the observation were recorded and the data are presented statically on various parameters for establishing the scientific interpretation.

The various parameters recorded such as Plant height, Root nodulation, Fodder yield, Nutrient build up and nitrogen fixed in soil has been recorded.

It was observed that that the different genotype varied significantly at 45 DAS and at harvest .Among forty germplasm the best ten of them were selected regarding their influence the fodder yield, Nutrient content, Protein content and other component.

As regard the nutrient content at different growth stages, some of the germplasm has perform very good and differed significantly superior compared to other germplasm under testing.

The nutrient content gradually decreased as the growth advanced to maturity from 45 DAS to the harvest of rice bean as fodder, N,P,K content were 0.467,0.051 0.325 and 0.383,0.055,0.149 respectively.

The protein content ranged from 6.29-21.17 % in nodules. Overall it was observed and recorded with respect to processed data statistically the genotype G-68 best which can be selected for further studies.

It can be well concluded that among various genotype selected for investigation has performed well. The yield. Nutrient content, nodule formation nutrient uptake etc. has been recorded in G-68,From the point of view of breeding characteristic such as root elongation, nodule formation, nutrient assimilation and fodder yield of any one genotype can be crossed with other genotype having different character.

VITA

The author of this thesis, Swati Tiwari D/o Shri R. S. Tiwari saw the light on 21st April 1987, at Distt. Seoni (Madhya Pradesh). She passed High School Certificate Examination of the C.G. Board, Raipur (Dhamtari) in the year 2002 with 75.4% marks and Higher Secondary School, C.G. Board Raipur (Dhamtari), in the year 2004 with 81% marks.

The author joined IGKVV, Raipur, in the year 2004 and completed the B.Sc. (Ag.) Degree in the year 2007-08 with 7.16 OGPA at 10 point scale. Subsequently after graduation she joined M.Sc. (Ag.) in Soil Science & Agricultural Chemistry from Jawaharlal Nehru Krishi Vishwavidyaya, Jabalpur in the year 2010, and cleared all the courses with first division (7.65 OGPA at 10 point scale) in the year 2012. During the course of her Post Graduate studies, she selected research problem on "Screening of ricebean germplasm lines, for their growth, quality and nitrogen fixing efficiency "which was duly completed by her and presented in this thesis.