CHARACTERISATION AND SYSTEMATIC EVALUATION OF GENETIC RESOURCES OF THE GENUS *Vigna*

KERALA AGRICULTURAL UNIVERSITY CENTRAL LIBRARY KAU P.O. THRISSUR

By

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THESIS

Submitted in partial fulfillment of the requirement
for the degree of

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COLLEGE OF HORTICULTURE
KERALA AGRICULTURAL UNIVERSITY
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2010

DECLARATION

I hereby declare that the thesis entitled **Characterisation and systematic evaluation of genetic resources of the Genus *Vigna*** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma fellowship or other similar title of any other university or society

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CERTIFICATE

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Introduction

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1 Introductıon

Vıgna belongıng to the famıly Legumınoseae ıs a large genus comprısıng of seven sub genera and over 150 specıes (Verdcourt 1970 Marechal and Baudoın 1978) The seven sub genera ın the genus *Vıgna* namely *Ceratotropıs Haydonıa Lasıopron Macrorhyncha Plectotropıs Sıgmoıdotropıs* and *Vıgna* were recognızed by Marechal and Baudoın (1978) Of these two sub genera *Vıgna* and *Ceratotrop s* contaın most of the ımportant cultıvated specıes The sub genus *Vıgna* ıncludes *Vıgna ungı ıc lata* (cowpea) and *V subterranea* (bambara groundnut) However most of the Asıan *Vıgna* specıes come under the sub genus *Ceratotrop s* and half of them are eıther domestıcated or cultıvated (Verdcourt 1970 Marechal and Baudo n 1978) The cultıvated specıes under the sub genus *Ceratotropıs* ınclude *Vıgna radıata* (mung bean or green gram) *V m ıgo* (urd bean or black gra n) *V ı n bellata* (r ce bean) *V aconıt folıa* (moth bean) and *V t lobata* Out of the 21 specıes of As an *Vıgna* 15 16 are found ın Ind a (Tomooka *et al* 2003) The occurrence and taxonomıcal ıdent f cat on of these spec es are stıll confusıng and a comprehens ve l st of spec es occurrı ng n Ind a has not been reported so far The closely related wıld specıes possess many useful genes whıch could be transferred to the cultıvated specıes Thıs s poss ble only when our knowledge about the relatıonsh ps of these specıes s well unde stood Th s can be ach eved only when the spec es ıdent ty ıs correct

Genetıc d versıty ıs normally assessed by common morphologıcal traıts However such morpholog cal tra ts are affected by env ronmental factors developmen al stage of the plant ype of plant ma erıal etc Th s necess ta es a h ghly rel able and prec se method for assess nen of gene c varıab l ty el nı ro e al effec s Assess nent of genet c dıversıty wıth bıochemıcal markers such as sozymes or molecular markers overcomes thıs problem The use of molecular markers allows the dırect assessment of genotypıc varıatıon at the DNA level Molecular markers have brought about phenomenal changes ın the area of plant bıotechnology by theır abılıty to produce unıque DNA profiles ın varıous crops The genes controllıng several traıts of agronomıc ımportance have been mapped and tagged These markers assıst ın breedıng programs and even ın ısolatıon of the gene of ınterest Marker analysıs also helps to analyze the global organızatıon of genetıc dıversıty wıthın a specıes

The present study entıtled Characterısatıon and systematıc evaluatıon of genet c resources of the genus *Vıgna* was taken up ın thıs background wıth the followıng objectıves

ı characterıze the avaılable accessıons of *Vıgna* germplasm at Natıonal Bureau of Plant Genet c Resources (NBPGR) Regıonal Statıon Vellan kkara Thrıssur us ng morphologıcal markers

confirm the results usıng b ochem cal and molecular markers n dıst nct varıants n d fferent specıes

ııı prepare a key for the ıdentıficat on of *V gna* spec es

Review of Literature

2 Review of Literature

2 1 Taxonomy of *Vigna*

Savi named the genus *Vigna* in 1824 after the professor of Botany at Pusa University Domenico *Vigna* (Baudoin and Marechal 1988)

Verdcourt (1970) separated the genus *Vigna* from *Phaseolus* and restricted the latter one to those American species with a tightly coiled style and pollen grains which lacked wide reticulation He also subd vided the genus into 8 sub genera and 9 sections

Verdcourt (1978) transferred the genus *Voandzeia* to *Vigna* on the grounds that it was nseparable from *Vigna* based on morphological characters

Marechal and Baudoin (1978) studied 177 taxa n *Vigna Phaseolus* complex and seve al smaller related genera us ng 161 morphological cytological floral and pollen characters and described the useful discriminating characters between the genus *V gna* and the genus *Phaseoli s* They observed that the genus *V gna* can be identified by the characters such as attachn ent of st pules to the stem either by its basal or central part contracted nflorescence rachis style prolonged beyond the stigma triporate pollen and large ret culat ons of the pollen ex ne w th granular infratectum They also reported that the genus *V gn* seemed relatively heterogeneous and contained 82 species d stributed among seven sub genera na nely *V gna Haydoi a Plectotrop s Ce ato rop s Las opron Sign o dotrop s* and *Macrorhyncl a* All he seven sub genera except *Las op o* and *Macrorhyncha* are d v ded nto sect ons The sub genus *Ceratot op s* could be d vided into 3 sections *A g la es Acon t fol ae* and *Ce atot op s* s b genus *Haydon a* nto 3 sect ons *Glossostyli s Haydo a a d M c o pe* sub genus *Plecto op s* nto 2 sections *Plectot op s* and

Psuedolibrechtsia sub genus *Sigmoidotropis* into 5 sections *Caracallae* *Condylostylis* *Leptospron* *Peduncılares* and *Sigmoidotropis* and sub genus *Vigna* into *Catiang* *Comosae* *Liebrechtsia* *Macrodontae* *Reticulatae* and *Vigna*

Pasquet (2001) concluded that the genus *Vigna* included approximately 80 species which were found throughout the tropics

2 2 Distribution of *Vigna* species

Marechal and Baudo n (1978) after class fying the genus *Vig a* into seven sub genera also proposed the main area of distribution of each sub genus Accordingly the sub genera *Vigna* *Haydonia* *Plectotropis* and *Macrorhynch a* are d stributed in Africa the sub genera *Lasiopro* and *Sigmoidotropis* in America and the sub genus *Ce at t op s* n Asia The sub genus *Ce atot op s* alone had ts ce t e of d vers ty in Asia and he ce called As an *V g a* They also reported three d st ict groups of cult vated *V g a* spec es t vo of which are of Af can orig n and the third As at c The Afi can groups each conta ned a s i g e spec es co vpea (*V g a g c lat*) ass gned o t e sub genus *V g a* a d sect o *Cat a g* a d bamba a g oundnut (*V s b e a ea*) to the sub ge us a d sect o *V g* Th e Asiat c groups were ass gned o the sub genus *C ot op s* by them and the cultivated species included *V adiata* (mung bean or green gram) *V m i go* (urd bean or blackgram) *V bellata* (rice bean) *V acon t folia* (moth bean) and *V t ilobata*

Engler (2001) listed 17 cult vated species n the genus *Vigna* along with the r place of orig n as g ven n Table 1

To nooka *et l* (2003) proposed a ev sed l st of cu t va ed and ld axa of As at c *V g* belo g to 3 sec ons d st bu ed n As a P c fc eg on Th e l st s presented Table 2

Table 1 Cultıvated specıes ın the genus *Vıgna*

Sl No	Botanıcal name	Common name	Place of orıgın
1	*Vıgna aco ıtıfolıa*	Moth bean	South Asıa
2	*V adenantha*		Pan tropıcal Natıve to Amerıca
3	*V angularıs*	Adzukı bean	East Asıa
4	*V antıllama*		Carıbbean
5	*V caracalla*	Sna l flower	South and Central Amerıca
6	*V hoseı*	Sarawak bean	South and South East Asıa east Afrıca
7	*V luteola*	Dalymple vıgna	South Amerıca
8	*V n ar na*	Dune bean	Pan tropıcal Natıve of Amerıca
9	*V mı ngo*	Urd bean black gram	South Asıa
10	*V radıata*	Mung bean green gram	South Asıa
11	*V reflexo pılosa va glab a*	Creole bean	South East Asıa
12	*V s bterra ea*	Bambara groundnut	Sub saharan Afrıca
13	*V tr lobata*	Junglı bean	South Asıa
14	*V t ne v a*	Tooapee	South and South East Asıa
15	*V ı bellata*	Rıce bean	South East Asıa
16	*V ng c lata*	Cowpea	South and South East Asıa and Afrıca
17	*V exıllata*	Zombı pea	Pan tropıcal and Natıve to Afrıca

Table 2 Revised list of taxa of Asiatic *Vigna* occurring in Asia Pacific region

Section	Species	Distribution
Angi lares	*V angi lar s* var *angi laris*	Japan Korea Ch na Bhutan Nepal V etnam
	V angi lar s var *n pponens s*	Japan Korea China Bhutan Nepal India (Himalayas)
	V dalzell a a	Ind a Srilanka
	V ex l s	Thailand
	V h rtella	North Ind a South East As a
	V m n ma	South East As a New Gu nea
	V nakash mae	North China Korea Japan
	V nepalens s	Bhutan East Nepal North East Asia
	V reflexo p losa var *glabra*	Ind a Maurit us Phil pp nes
	V reflexo p losa var *reflexo p losa*	Japan (Ryukyu) China South East As a New Gu nea
	V r uki ens s	Japan Ch na
	V ten ca l s	Tha land Myanmar
	V tr nerv a var *tr nerv a*	Madagascar South Ind a Srilanka Myanmar Tha land Malays a Indones a New Gu nea
	V tr ne v a var *bo rneae*	Sou h Ind a
	V mbella a (Cult vated)	Sub rop cal and warm temperate As a
	V mbella a (W ld)	North East Ind a Myanmar Tha land Indo Ch na
Ce atotrop s	*V g and flo a*	Tha land Cambod a
	V m ngo va *m ngo*	South As a
	V m ngo var *sylves r s*	Ind a Myanmar Tha land
	V ad ata var *rad ata*	As a Africa and Aus al a
	V rad ata var *s bloba a*	As a Africa and Aus ral a
	V s braman ana	Ind a
Acon t fol ae	*V acon t fol a*	South As a
	V a d cola	Srilanka
	V khandale s s	Ind a
	V s p laceae	Ind a Srila ka Indones a Ne v Gu nea
	V loba a	South Ind a Srilanka

The Asia Pacific region is represented not only by the taxa of *Vigna* belonging to sub genus *Ceratotropis* but also by several species from other sub genera of the genus *Vigna* (Tomooka *et al* 2003) which are presented in Table 3 below

Table 3 *Vigna* species belonging to sub genera other than *Ceratotropis* occurring in Asia Pacific region

Sub genus	Species
Sigmoidotropis	*V adenantha*
Macrorl yncha	*V grahamiana*
Plectotropis	*V vexillata*
Vigna	*V ingi ici lata* *V pilosa* *V hosei* *V lı teola* *V la iceolata* *V n a na* *V pa keri*

Arora (1985) eported the d stribut o al ange of *V g a* spec es n 4 phytogeograph cal zoi es n Ind a amely Weste ı Ghats Easten Ghats North Eastern reg on ınd the Weste ıı H malayas The spec es under ge ıus *V g a* occup ed over 16 diffe ent vegeta on ypes largely b ot c/b oedaph c status He also epo ıed thıt As at c *I g a* species const tuted a econo ıı cally ıportı t group of cult vated and v ld spec es v th rich d ve s ty n Ind a The 14 spec es of *V g* a ıd tl e r ld forms belongin to 4 sub gene a of tl e genus *I g* l s ed by Arora as occurr ıg n I d a a e p esen ed Table 4

Subsequen ly Babu *l* (1985) l s ed ?3 *I g* sp ec es fou d I d a clud g tl e

5 species wh ch had their orig n in other ountries They were *V vex llata V n arina V lı teola V g al am ana V clarkeı V pılosa V ıngı culata V dalzellıana V kha ıdale s s V acor t folıa V un bellata V tı lobata V l a ı a ıa V bo eae V glabresce ıs V ı ad ata V n ngo V s blobata V adena tl a V hoseı V rıccardıana V praın aı a and V angı larıs*

Table 4 *Vıgna* specıes and their wıld forms occurrıng ın Ind a

Spec es	W ld form
Sub genus *Ce atot op s*	
Vıg ıa go	*V ı go* var *sylvest ıs*
V ad ata	*V rad ata* var *sı blob ta* and *V ad ata* var *setı los*
V ı n bellata	*V n bellata* var *g ac l s*
V a g la s	No w ld form
V co fol	W ld form s m lar to cult vated type
V t lob t	W ld form s m lar to cult vated type
V lal ell a a	Only w ld types occur much akın to *I u bclla a* wıld types
V g a l s	O ıly v ld types occur much akın o *V l a go* complex
Sub genus *Plec ot op s*	
V c pe s	O ly v ld types presen
Sub genus *M c o yl c*	
V g al s	Only v ld ypes prese ı
Sub genus *I g a*	
V p losa	Only v ld ypes present
I a	Only ld types presen
I g la	No v l l ypes oc I d a
I l ol	Only v l l ypes ı ese

2 3 **Morphological and Palyanological characterisation of *Vigna* species**

The As an *V g a* are considered to be a norphologically homogeneous group having specialized and complex floral organs and recently evolved (Baudoin and Marechal 1988)

Tateish and Ohashi (1990) summarized the key morpholog cal characters recognized for the sub genus *Ceratot opis* such as peltate stipule keel petals curved to the left in the upper part presence of pocket on the left keel petal style extending beyond the stigma as a beak and pollen gra ns w th coarse ret culate sculpturi g

Tateish (1996) demonstrated three groups *v z ig la s i bellata* (azuki bean group) *ad ata n go* (mung bean group) and *acoi it fol a tr lobata* (moth bean group) in Asian *V g a* based on the pos t on of cotyledons dur ng germ nat on as well as the pet olate or sess le natu e of first and second leaves The leaves were reported to be sessile n *V m go* and *V d at* and petiolate i *V l ellat* a id *V co t fol* S m la results we e also reported by several other vorkers (Jaaska and Jaaska 1990 Kaga *et al* 1996 Tomooka *et al* 1996 Konarev *et al* 2007)

Study d ve s ty of o p holo ical characte s 14 w ld *V g a* spec es from Ind a by B sl t *et l* (2005) revealed t e presence of 3 d st ngu shable groups n the sub genus *Ce a ot op s* All the spec es n *n go ad t* g oup except *V kl a l le s* namely *V d* var *s blob ta l d ta* var *se lo a V go* var *syl c t s* and *V l* sho ve l greater ho nology vegeta ve mo pholo y and growth hab t They l o ve er d ffered n flo ve pod a d seed characters W th species va iat on was h gher n *V n go va l* popu at on an l three d st nct clus ers could be dent fed o i mul varia e a alys s

Palynological attributes of plants have attracted many researchers in recent time Nyananyo (1990) Edeoga *et al* (1996 1998) and Edeoga and Gomina (2001) have utilized pollen attributes to establish relationships among certain groups of flowering plants According to them the main characters of taxonomic value in pollen were the number and position of furrows morphology of pollen wall symmetry shape and size of pollen grains

Mbagwu and Edeoga (2006) conducted palynological studies in eight *Vigna* species of Nigeria Results of the investigation revealed that the pollen grains were circular and psilate in *Vigna reticulata* circular and echinate in *V racemosa* and *V unguiculata* elliptic and monocolpate in *V ambacensis* and *V vexillata* circular and polycolpate in *V subterranean* and circular and dicolpate in *V triloba* and *V gracilis* Hence the species could be identified based on the type and shape of pollen grams The specific features of pollen grains in these taxa could be evolutionary modifications often inherited to determine the mode of pollination and thereby perpetuate a particular group of plants in a given environment

The wild relatives of crop plants are sources of important genes for agriculture Bruchid beetles such as *Callosobruchus chinensis* (azuki bean weevil) and *C maculatus* (cowpea weevil) cause serious damage to several leguminous crops including cultivated *Vigna* species such as cowpea mung bean urd bean and rice bean during storage (Singh *et al* 1985 Fernandez and Talekar 1990)

Lambrides and Imrie (2000) screened 26 accessions of mung bean for resistance to 4 bruchid species On the basis of the percentage of damaged seeds all the accessions were found to be highly susceptible to strains of *C llo ob cl s c l t s* and *C cl c s* Three access ons of *I a l a blol* sl e l res s a e

Tomooka *et al* (2003) evaluated germplasm collection representing 76% of known taxa in the genus *Vigna* for resistance to bruchid beetles Seven taxa consisting of 24 accessions were found to be resistant to *C maculatus* No resistance was found in accessions of mung bean whereas complete resistance was seen in *V umbellata*

2 4 Biochemical characterisation

Isozymes form an effective marker system that can clarify taxonomic and phylogenetic relationships among plant species (Mowrey and Werner 1990 Jaaska 1994) Isozyme data have been used in the genus *Vigna* for taxonomical studies Jaaska and Jaaska (1988) used the enzymes glutamate oxaloacetate transaminase (GOT) and superoxide dismutase (SOD) to assess the variations in the species belonging to *Vigna* and *Phaseolus*

Panella and Gepts (1992) carried out isozyme analysis in *Vigna unguiculata* to determine the extent of genetic relationships and genetic diversity between cultivated and wild cowpea Thirty four cultivated as well as 56 wild accessions of cowpea and 6 accessions of five related *Vigna* species were analysed Ten enzyme systems were polymorphic within cowpea About 14 of 24 putat ve loci (85%) were polymorphic in wild *V iguici lata* but only one (4%) was polymorphic in cultivated cowpea In the five related *Vigna* species 21 out of 24 bands showed 88 percent polymorphism

The evolutionary relationships between cultivated and wild species of Asiatic *Vigna* were investigated using isozyme variation pattern of peroxidase catalase and seed protein polymorphism by Sehgal and Chandel (1992) *V radiata* and *V mungo* were found to be two distinct species which had independently evolved from wild progen tors *V radiata* var *si blobata* and *V n go* var *syl est is* respect vely They showed remarkable s milarit es n isozyme profiles part cularly n tl e number and pos t on of bands as well as Rf values The wild putative forms of *V umbellata* *V aconitifolia* and *V trilobata* occurring in natural habitats also appeared to be quite distinct with fewer bands

Sonnante *et al* (1996) assessed the relationships within and among *Vigna unguiculata* *V vexillata* and seven species belonging to the section *Vigna* using nine isozyme systems and suggested a very low genetic distance between *V luteola* and *V marina*

Sonnante *et al* (1997) studied 19 accessions of *Vigna luteola* 5 of *V marina* subsp *oblonga* and 4 of *V marina* subsp *marina* using isozymes to obtain an insight into the genetic relationships within and among these taxonomic entities Seven out of 13 isozyme loci were found to be polymorphic Both species showed very low genetic diversity indices

Selvi *et al* (2003) studied the genetic variation among 52 accessions of *Vigna* species that included 15 accessions of *V unguiculata* 15 of *V mungo* 19 of *V radiata* and one each of wild species *V aconitifolia* *V trilobata* and *V radiata* var *sublobata* belonging to the sub genera *Ceratotropis* and *Vigna* using morphological characters and five isozyme markers The clusters obtained based on morphological characters and isozyme markers were compared The clustering based on morphological traits grouped the various sub genera of *Vigna* into a single cluster but failed to reflect the real genetic relationships among the different species The clustering based on isozyme variations (superoxide dismutase aspartate aminotransferase isocitrate dehydrogenase peroxidase and alpha esterase) however revealed the true taxonomic relationships by grouping *Ceratotropis* and *Vigna* species into two distinct clusters This indicated that variations in isozymes can be exploited to understand the extent of the genetic diversity and relationships among the accessions of *Vigna*

2 5 Molecular charactensation

DNA markers because of the r hentable nature were found to act as versatile tools n the fields like taxonomy phys ology embryology genetic engineenng etc Major applications of these DNA markers in the field of genetics and plant breeding are in (i) diversity analysis and phylogenetic studies (ii) mapping genes and (iii) marker assisted selection (MAS) provide an opportunity to characterize genotypes and to measure genetic relationships more precisely than other markers (Soller and Beckmann 1983) Among the DNA markers RFLP was the first and still the most commonly used marker for the estimation of genetic diversity of eukaryotic spec es The recently developed PCR based multiple loci marker technique wh ch includes random amplified polymorphic DNA (RAPD) amplif ed fragment length polymorph sm (AFLP) inter simple sequence repeat (ISSR) and more recently s mple sequence repeat (SSR) or microsatellites (Gupta and Varshney 2000) are play ng increasingly important roles in this type of research Multiloci system l ke RAPD AFLP ISSR markers because of their whole genome coverage are cons dered good for genet c d versity and phylogenetic analysis

AFLP techn que was used for detecting intra specific differences among and v thin *V g ia* species (Yee *et al* 1999 Yoon *et al* 2000 Zong *et al* 2003) Aj bade *et al* (2000) stud ed the ut lity of ISSR n distinguish ng taxa w th n genus *V gna* They were able to clearly differentiate sub generic divis ons w thin *V gi a* using ISSR markers

Tomooka *et al* (2001) stud ed the cult vated w ld weedy and complex populat ons of *V g a a g la is* n Japan using AFLP and RAPD analyses and revealed a clinal var ation th s spec es The genet c d vers ty at the DNA level decreased from the v ld to weedy to ult a ed populations

Doi *et al* (2002) used 863 polymorphic fragments obtained from AFLP analys s to determine the genetic diversity in different species of sub genus *Ceratotropis* The phylogenetic tree obtained revealed three groups of pecies that corresponded to the three sections in *Ceratotropis* Among the three sections *Vigi a trinervia* had a central position and can be cons dered as a useful species to facil tate gene transfer among sections of the sub genus *Ceratotropis* All the species in section *Aconitifoliae* and section *Ceratotropis* were found to be genetically distant from each othei However those of *Angi lares* were observed to be closely related having only lower genetic d stance than other sections *V mi ngo* and *V rad ata* were h ghly diverged represent ng two distinct phylogenetic lineages

Nine wild taxa from genus *V gna* sub genus *Ceratotropis* were studied by Saravanakumar *et al* (2004) us ng AFLP and RAPD analysis The results supported the taxonom c revis on of *Vigna rad ata* var.s *blobata* and *V tri ervia* into two distinct species The new cons deration of *V boi ieae* as a variety of *V tr erv a* was also supported

Souframanien and Gopalakrishnan (2004) suggested that ISSR markers were more eff cient than the RAPD assay as they detected 57 4 percent polymorphic DNA markers in *V i ngo* as compared to RAPD which detected only 42 7 percent polymorph sm

Chattopadhyay *et al* (2005) also stud ed d versity in *V rad ata* genotypes using ISSR markers They suggested that even though the polymorphism among the varieties was moderate t was high (83%) when the whole germplasm was considered and ISSR markers were more effic ent than RAPD

Seehalak *et al* (2006) stud ed the gene c divers ty n *V g a* germplasm of Thailand us ng AFLP markers and clar fed the nter and ntra spec f c d vers ty and relationships a no he spec es The results s ggested that cul a ed *V bella a* and *V n go* evolved from wild relatives in a single domestication event *Vigna umbellata* was observed to be poorly differentiated from its wild and weedy relatives compared to *V mi ngo*

Wang *et al* (2008) were of its view that the phylogenetic relationships in the USDA *Vigna* germplasm collection were somewhat unclear and their genetic diversity had not been measured empirically To reveal the inter specific phylogenetic relationships and to assess their genetic diversity 48 access ons representing 12 *Vigna* species were selected and 30 gene derived markers from legumes were employed Two d fferent dendrograms were generated from DNA fragment and Sequence data respectively The results from these two dendrograms supported each other and showed similar phylogenetic relationsh ps among the *Vigna* species nvestigated The accessions clustered into four major groups and 13 subgroups Each subgroup represented a sub genus or a species Based on the results they suggested that more attent on should be paid to sub species wild forms and/or botanical varieties in order to expand the genetic diversity of *Vig a* germplasm in the USDA collect ons

Ruchi *et al* (?009) used RAPD markers to study sub structure and gene c d fferent at on among 31 populations belonging to 14 Asiat c *V gna* spec es Molecular phylogenet c relationships among the spec es of radiata mungo complex namely black gram (*V r i igo*) green gram (*V ad ata*) *V rad ata* var *si blobata* *V rad ata* var *seti losa* *V mi r go* var *sylvestris* and *V haimana* were stud ed by cluster analysis Two d st nct groups were recognized w thin the complex with populat on samples of *V l a ia ia* forming one cluster Furtl er *V l a ia ia* appeared to be equ distant from both *V ad ata* and *V go*

Materials and Methods

3 Materıals and Methods

The present ınvestıgatıon whıch ıncludes the followıng three experıments were conducted ın the Department of Plant Breedıng and Genetıcs College of Hortıculture Kerala Agrıcultural Unıversıty Vellanıkkara and the Natıonal Bureau of Plant Genetıc Resources (NBPGR) Regıonal Statıon Thrıssur durıng the perıod 2005 2008

1 Morphologıcal characterısatıon

2 Bıochem cal characterısatıon and

3 Molecular characterısatıon

Morphologıcal characterısatıon

The one hundred and fifty accessıons of *Vıgna* ıncludıng the cultıvated specıes ma nta ned at the Nat onal Bureau of Plant Genet c Resources Regıonal Statıon Thrıssur were selected for the study The detaıls of each accessıon are presented ın Table 5

These access ons vere ra sed at NBPGR ın completely randomızed desıgn (CRD) wıth two repl cat ons durıng *kl a f* 2006 as pot culture The plants were thınned to three/pot on 10^{th} day after sow ng Recommended agronomıc practıces were followed

Observatıons on 48 qualıtat ve and 24 quantıtat ve characters were made at varıous phenophases of the crop from all the selected accessıons The descrıptor l st developed at NBPGR was used for recordıng the observat ons The descrıptor and the descrıptor states are presented n Table 6 Based on the qualıtat ve characters the 150 accessıons were grouped ınto dıfferent taxa

Table 5 Accessions under the taxa *Vigna* used for study

Sl No	Code for taxa	Accession	IC Number	Source of collection
1	V	New *Vigna* species	277045	Maharashtra
2	Va	*Vigna acon tifolia*	417347	Tam l Nadu
3	Vd1	*Vigna dalzellia ia*	247408	Kerala
4	Vd2	*Vigna dalzelliana*	203864	Kerala
5	Vd3	*Vigna dalzelliana*	210555	Kerala
6	Vd4	*Vigna dalzelliana*	210556	Kerala
7	Vd5	*Vigna dalzelliana*	210559	Kerala
8	Vd6	*Vigna dalzell ana*	210579	Kerala
9	Vd7	*Vig a dalzell a a*	248168	Karnataka
10	Vd8	*Vig a dalzellia a*	248195	Karnataka
11	Vd9	*Vigna dalzellia a*	248261	Goa
12	Vd10	*V gna dalzell ana*	248346	Maharashtra
13	Vd11	*Vigna dalzell a a*	336206	Kerala
14	Vd12	*V gna dalzell ana*	253961	Kerala
15	Vd13	*Vigna dalzell a a*	253913	Rajasthan
16	Vd14	*V g a dalzell a a*	253911	Rajasthan
17	Vd15	*V gna dalzell a a*	277025	Maharashtra
18	Vd16	*V g a dalzellia ia*	277060	Goa
19	Vd17	*V gna dalzell a a*	539795	Karnataka
20	Vd18	*V g a dalzelli na*	539796	Karnataka
21	Vd19	*Vig ia dalzell a ia*	539806	Kerala
22	Vd20	*V g a dalzell a a*	550577	Kerala
23	Vd21	*V g a lalzell a ia*	541388	A & N Islands
24	Vg	*V gna glabresce s*	251372	Madhya Pradesh
25	Vh1	*V gna l a a a*	251376	Madhya Pradesh
26	Vh2	*V g a l a a a*	251378	Madhya Pradesh
27	Vh3	*V gna l a n a a*	251381	Madhya Pradesh
28	Vh4	*V gna l a n a a*	349905	Kerala
29	Vh5	*V gi a l a a a*	276985	Madhya Pradesh
30	Vh6	*V g ia l ain ana*	276999	Maharashtra
31	Vh7	*V gna l ai ia a*	277007	Mal arashtra
32	Vh8	*V g a l a a a*	331438	Orissa
33	Vl 9	*V g a l a a a*	331448	Or ssa
34	Vh10	*V g a l a a a*	331460	Chhatt sgarh
35	Vk	*V g a kl a dale s s*	406504	Maharashtra
36	Vma	*I g a a*	539828	A & N Islands
7	Vmu1	*I g oo ir go*	31441	Orissa

Sl No	Code for taxa	Access on	IC Number	Source of collection
38	Vmu2	*Vigna mi ngo* var *mi ngo*	331447	Orissa
39	Vms1	*Vig a mi igo* var *sylvestris*	248294	Goa
40	Vms2	*Vig a i i ngo* var *sylvestris*	248326	Maharashtra
41	Vms3	*Vigna mi ngo* var *sylvestris*	248331	Maharashtra
42	Vms4	*Vigna n ungo* var *sylvestris*	248343	Maharashtra
43	Vms5	*Vigna m ingo* var *sylvestris*	256135	Kerala
44	Vms6	*Vigna mungo* var *sylvestris*	253907	Rajasthan
45	Vms7	*Vigna mungo* var *sylvestris*	277014	Maharashtra
46	Vms8	*V gna mi ngo* var *sylvestris*	277021	Maharashtra
47	Vms9	*Vigna mungo* var *sylvestris*	277026	Maharashtra
48	Vms10	*Vigna m ngo* var *sylvestris*	277031	Maharashtra
49	Vms11	*Vigna m ingo* var *sylvestris*	277036	Maharashtra
50	Vms12	*Vigna m ngo* var *sylvestr s*	277039	Maharashtra
51	Vms13	*Vigna i u ngo* var *sylvestr s*	277041	Maharashtra
52	Vms14	*V g a n i ngo* var *sylvest s*	277044	Maharashtra
53	Vms15	*Vig a mi go* var *sylvestris*	277053	Maharashtra
54	Vms16	*Vigna mi ngo* var *sylvestr s*	277055	Maharashtra
55	Vms17	*V g a n go* var *sylves s*	277057	Maharashtra
56	Vms18	*Vigna m ngo* var *sylvestris*	277061	Goa
57	Vms19	*Vigna ngo* var *syl estr s*	277084	Maharashtra
58	Vms20	*V g a igo* var *sylvestr s*	539798	Karnataka
59	Vms21	*V gna n ngo* var *sylvestr s*	539800	Karnataka
60	Vms22	*Vigna mi go* var *sylvestr s*	539801	Karnataka
61	Vp	*I g a p losa*	541389	A & N Islands
62	Vr1	*V gna ad ata* var *ad ata*	251412	West Bengal
63	Vr2	*V g a ad ata* var *ad ata*	251413	West Bengal
64	Vr3	*Vig a ad ata* var *ad ata*	251414	West Bengal
65	Vr4	*V gna ad ata* var *a l ata*	251422	West Bengal
66	Vr5	*V g a rad ata* var *rad ata*	251424	West Bengal
67	Vr6	*V gna ad ata* var *rad ata*	251426	West Bengal
68	Vr7	*V gna ad ata* var *ra liata*	349699	Kerala
69	Vrs1	*V gna radiata* var *s blobata*	202538	Kerala
70	Vrs2	*V gna rad ata* var *s blobata*	202580	Tamil Nadu
71	Vrs3	*I g a ad ata* var *s blobata*	202643	Kerala
72	Vrs4	*V gna ad ta* var *s bloba a*	247406	Kerala
73	Vrs5	*V g a ad ata* var *s blobata*	210554	Kerala
74	Vrs6	*I g a ad ata* var *s blob ta*	251418	Maharashtra
75	Vrs7	*V g a ad ata* var *s bloba a*	?81164	Kerala
76	Vrs8	*I g a a l a* 1 *s bloba*	28116?	Kerala

Sl No	Code for taxa	Accession	IC Number	Source of collection
77	Vrs9	*Vigna radiata* var *sublobata*	324496	Kerala
78	Vrs10	*Vigna ıadiata* var *sublobata*	322306	Kerala
79	Vrs11	*Vigna radiata* var *s blobata*	351407	Tamil Nadu
80	Vrs12	*Vigna radiata* var *sublobata*	331457	Chhattisgarh
81	Vrs13	*Vigna radiata* var *sı blobata*	539805	Kerala
82	Vrs14	*Vigna radiata* var *sublobata*	550576	Kerala
83	Vrs15	*Vigna radiata* var *sublobata*	248344A	Maharashtra
84	Vse1	*Vigna radiata* var *set ılosa*	251419	Maharashtra
85	Vse2	*Vigna radiata* var *set losa*	251420	Madhya Pradesh
86	Vse3	*Vigna radiata* var *setulosa*	251421	Madhya Pradesh
87	Vse4	*Vigna rad ata* var *set ılosa*	251423	Gujarat
88	Vse5	*Vigna ıad ata* var *set losa*	351404	Kerala
89	Vse6	*V gna radiata* var *set losa*	277058	Goa
90	Vst1	*V gna stipi lacea*	202559	Tamil Nadu
91	Vst2	*V gna st pi lacea*	256259	Kerala
92	Vst3	*Vigna st pi lacea*	324552	Tamil Nadu
93	Vsb1	*Vig ıa sı brama ıana*	253920	Rajasthan
94	Vsb2	*V g a sı b a a a a*	253926	Rajasthan
95	Vsb3	*V gna s bran a ıana*	253930	Rajasthan
96	Vt1	*V g a t ılobata*	251435	Gujarat
97	Vt2	*V gna t lobata*	251436	West Bengal
98	Vt3	*V gna t ılobata*	251438	Tamil nadu
99	Vt4	*V g ıa t ılobata*	349701	Tam l Nadu
100	Vt5	*V g a t lobata*	276983	Madhya Pradesh
101	Vt6	*V g a t lobata*	351406	Tam l Nadu
102	Vt7	*Vig a t lobata*	331436	Orissa
103	Vt8	*V g a t lobata*	331437	Or ssa
104	Vt9	*V gna tr lobata*	331453	Chhatt sgarh
105	Vt10	*V gı a tr lobata*	331454	Chhatt sgarh
106	Vt11	*Vigna tr lobata*	331456	Chhatt sgarh
107	Vt12	*Vigna t lobata*	541215	Tamil Nad
108	Vt13	*V gı a tr lobata*	541211	Tamil Nadu
109	Vtb1	*Vig a tr e v a* var *bo neae*	247407	Kerala
110	Vtb2	*V g a t nerv a* var *bo rı eae*	210574	Kerala
111	Vtb3	*V g a e v a* var *bo r eae*	264289	Kerala
112	Vtb4	*I g a t e a* var *bo eae*	248296	Goa
113	Vtb5	*V g a t erv a* var *bo eae*	249023	Kerala
114	Vtb6	*I g a e a* var *bo eae*	406509	Kerala
115	V b7	*V g a t e* var *bo eae*	406510	Ke ala

Sl No	Code for taxa	Accession	IC Number	Source of collection
116	Vtb8	*Vigna trinervia* var *bourneae*	349700	Kerala
117	Vtb9	*Vig ıa tı inerv a* var *bourneae*	349704	Kerala
118	Vtb10	*V gna trinervia* var *bourneae*	349885	Kerala
119	Vtb11	*Vigna trinervia* var *bourneae*	281163	Kerala
120	Vtb12	*Vigna trinervia* var *bourneae*	280784	Kerala
121	Vtb13	*Vigna trinervia* var *bourneae*	331442	Orissa
122	Vtb14	*Vigna trinervia* var *bourneae*	372379	Kerala
123	Vtb15	*Vigna trinerv a* var *bourneae*	372406	Kerala
124	Vtb16	*Vigna trı ıerv a* var *bourneae*	333605	Kerala
125	Vtb17	*Vigna trinervia* var *boı rneae*	539792	Karnataka
126	Vtb18	*Vigna trine via* var *bourneae*	539793	Karnataka
127	Vtb19	*V gna trinervia* var *boı neae*	550575	Kerala
128	Vtt	*V gna trı ıervia* var *trinervia*	337486	Kerala
129	Vu1	*V gna ı mbellata*	251439	Assam
130	Vu2	*V g ıa ı mbellata*	251440	Assam
131	Vu3	*V gna ı mbellata*	251441	Assam
132	Vu4	*V gı a n bellata*	251442	New Delh
133	Vu5	*V gna bellata*	251443	New Delh
134	Vu6	*Vig a mbellata*	251444	New Delhi
135	Vu7	*Vigna ı mbellata*	251445	New Delhi
136	Vu8	*Vig a ı ı bellata*	251446	New Delhi
137	Vu9	*V gı a mbellata*	251447	Ne v Delh
138	Vu10	*V gna mbellata*	349904	Kerala
139	Vu11	*V g ıa n bellata*	324483	Kerala
140	Vug1	*V gı a mbellata* var *g ac l s*	251370	Madhya Pradesh
141	Vug2	*V g a bellata* var *g ac lis*	331618	Himachal Pradesh
142	Vug3	*Vigna ı bellata* var *gracil s*	331621	H machal Pradesh
143	Vug4	*V gı a bellata* var *g ac l s*	331624	H machal Pradesh
144	Vun1	*V g a ı ng c lata*	349906	Kerala
145	Vun2	*Vig a gı c lata*	298665	Kerala
146	Vun3	*V g a ng c lata*	331439	Orissa
147	Vv1	*V gna ex llata*	248344	Maharashtra
148	Vv2	*V gna vex llata*	248345	Maharashtra
149	Vv3	*V g a vex llata*	406507	Kerala
150	Vv4	*V g a ve lla a*	349723	Tam l Nadu

Table 6 Descriptor and descriptor states used for recording observations

Sl No	Character	Descriptor state	Description
1	Days to emergence		
2	Type of seed germination	1	Epigeal
		2	Hypogeal
3	Colour of hypocotyl	1	Green
		2	Greenish purple
		3	Light purple
		4	Purple
4	Vigour of seedling	1	Poor
		2	Intermediate
		3	Vigorous
		4	Very vigorous
5	Shape of primary leaf	1	Ovate
		2	Ovate lanceolate
		3	Lanceolate
		4	Cordate
		5	Cordate with cuneate tip
		6	Deltoid
6	Primary leaf length (cm)		
7	Primary leaf width (cm)		
8	Colour of primary leaf petiole	1	Green
		2	Greenish purple
		3	Purple
9	Nature of attachment of primary leaf	1	Petiolate
		2	Sub sessile
10	Habit	1	Annual
		2	Perennial
11	Growth habit	1	Erect
		2	Semi erect
		3	Spreading
		4	Climbing
12	Growth pattern	1	Determinate
		2	Indeterminate
13	Leafiness	1	Sparse
		2	Intermediate
		3	Abundant
14	Pubescense of leaf	1	Glabrous
		2	Very sparsely pubescent
		3	Sparsely pubescent
		4	Moderately pubescent
		5	Densely pubescent

Sl No	Character	Descript or state	Description
15	Colour of petiole	1	Green
		2	Green with purple tinge
		3	Greenish purple
		4	Purple
16	Colour of petiole at leaf blade joint	1	Green
		2	Greenish purple
		3	Purple
17	Colour of pet ole at base	1	Green
		2	Greenish purple
		3	Purple
		4	Dark purple
18	Pubescence of petiole	1	Glabrous
		2	Pubescent
		3	Moderately pubescent
		4	Densely pubescent
19	Colour of petiolule	1	Green
		2	Green sh purple
		3	Purple
20	Terminal petiolule length (cm)	1	Short (<2 0cm)
		2	Med um (2 1 3 0cm)
		3	Long (>3 1cm)
21	Prominence of leaf vein	0	Not prominent
		1	Prominent
22	P gmentation of leaf vein	0	Not pigmented
		1	Pigmented
23	Lob i g of erminal leaflet	0	Un lobed
		1	Very shallowly lobed
		2	Shallowly lobed
		3	Intermediately lobed
		4	Deeply lobed
		5	Very deeply lobed
24	No of lobes in terminal leaflet		
25	Term nal leaflet length (cm)		
26	Terminal leaflet width (cm)		
27	Shape of terminal leaflet tip	1	Round
		2	Sub acute
		3	Obtuse
		4	Acute
		5	Rhombo d
28	Sl ape of terminal leaflet lobe	0	No lobes
		1	Lanceolate
		2	Broa lly o ate

Sl No	Character	Descript or state	Description
		3	Ovate
		4	Rhombic
		5	Acute
		6	Rhomboid
29	Petiole length (cm)	1	Short < 6 0cm)
		2	Intermediate (6 1 12 0cm)
		3	Long (> 12 1cm)
30	Size of stipule	1	Small
		2	Medium
		3	Large
		4	Minute
31	Shape of st pule	1	Ovate
		2	Ovate lanceolate
		3	Lanceolate
32	Presence of ligule	0	Absent
		1	Very minute
		2	Small
33	Twining tendency	1	None
		2	Slight
		3	Intermediate
		4	Pronounced
34	No of primary branches		
35	Branch ng pattern of primary branches	0	None
		1	Basal
		2	Central
		3	Top
		4	All over
36	Colur of stem	1	Light green
		2	Green
		3	Purplish green
		4	Purple
37	Pubescence of stem	1	Glabrous
		2	Puberulent (Sparsely pubescent)
		3	Moderately pubescent
		4	H ghly pubescent
		0	Stem glabrous
38	Colour of stem hair	1	Wh te
		2	Bro vn
39	Days to flo ven ıg		
40	Posit o of racen e	1	Mostly above ca opy
		2	In upper canopy

Sl No	Character	Descript or state	Description
		3	Throughout canopy
41	Colour of flower	1	Pale yellow
		2	Greenish yellow
		3	Yellow
		4	Golden yellow
		5	Violet
42	Colour of calyx	1	Green
		2	Purplish green
		3	Greenish purple
43	Colour of corolla	1	Yellow
		2	Green sh yellow
		3	Green purpl sh yellow
		4	Green with purple tinge
		5	Violet
44	Size of flower bud	1	Small (<2 0sq cm)
		2	Medium (2 0 4 0sq cm)
		3	Large (>4 0sq cm)
45	Size of bracteole	0	Absent
		1	Minute (<0 5mm)
		2	Small (0 5 1 0mm)
		3	Medium (> 1 0mm)
46	Shape of bracteole	0	Absent
		1	Ovate lanceolate
		2	Lanceolate
47	No of flowers/raceme		
48	Length of keel pocket (mm)	0	Absent
		1	Minute (<0 1mm)
		2	Short (0 1 0 2mm)
		3	Medium (0 21 0 3mm)
		4	Long (>0 4mm)
49	Colour of peduncle	1	Green
		2	Greenish purple
		3	Purple
50	Pubescence of peduncle	1	Glabrous
		2	Sparsely pubescent
		3	Moderately pubescent
51	Peduncle length (cm)	1	Short (< 8 0cm)
		2	Medium (8 1 12 0cm)
		3	Long (12 1 20 0cm)
		4	Very long (> 20 1cm)
52	No of pods peduncle		
53	Nature of pod attachment to pedu cle	1	Erec

Sl No	Character	Descript or state	Description
		2	Horizontal
		3	Horizontal pendent
		4	Pendent
		5	Sub erect
54	Colour of immature pod	1	Pale green
		2	Light green
		3	Intermediate green
		4	Dark green
55	Colour of mature pod	1	Straw
		2	Tan
		3	White
		4	Cream
		5	Light brown
		6	Brown
		7	Dark brown
		8	Brown and black
		9	Black
		10	Others
56	Days to first pod maturity	1	Very early (<60 days)
		2	Early (61 80 days)
		3	Med um (80 100 days)
		4	Late (101 120 days)
		5	Very late (>120 days)
57	Pubescence of pod	1	Glabrous
		2	Sparsely pubescent
		3	Moderately pubescent
		4	Densely pubescent
58	Curvature of pod	1	Straight
		2	Slightly curved
		3	Curved (sickle shaped)
59	Pod length (cm)	1	Short (< 3 0cm)
		2	Intermediate (3 0 5 0cm)
		3	Long (5 1 8 0cm)
		4	Very long (> 8 1cm)
60	Shape of pod beak	1	Pointed
		2	Blunt
61	Cross sect on of pod	1	Sem flat
		2	Round
		3	Others
62	No of seeds pod		
63	Shape of seed	1	Ro d
		2	Rectangular

Sl No	Character	Descript or state	Description
		3	Oblong
		4	Elliptic
		5	Kidney shaped
64	Colour of seed		As visible
65	Lustre on seed surface	0	Absent
		1	Present
66	Mottling on seed surface	0	Absent
		1	Slight
		2	Intermediate
		3	Heavy
67	100 seed weight (g)		
68	Seed length (mm)		
69	Seed width (mm)		
70	Shape of hilum	1	Concave
		2	Plain
		3	Convex
		4	Others
71	Hilum length (mm)	1	Short
		2	Intermediate
		3	Long
72	Seed yield/plant (g)		

3 1 1 Statistical analysis of morphological data

Cluster analysis was carried out using the data on all qualitative characters except colour of seed The color of the seed was recorded by v sual observation without any standard scores hence not included for the analysis The genetic associat ons among the accessions were estimated by Jaccard s similarity coefficients (Jaccard 1908) using NTSYS pc version 2 1 (Rohlf 1992) Based on the s milarity matrix cluster analysis was performed and dendrogram was constructed by unweighted pair group method (UPGMA) (Sneath and Sokal 1973)

The summary statist cs *viz* mean standard deviat on and standard error for the various quantitative morphological parameters of all the 150 accessions were worked out Based on quantitative characters *viz.* pr mary leaf length primary leaf w dth terminal pet olule length terminal leaflet length terminal leaflet w dth petiole length days to flowering size of flower bud size of bracteole number of flowers per raceme keel pocket length peduncle length number of pods per peduncle pod length number of seeds per pod hundred seed we ght seed length seed width h lum length and seed yield per plant group ng of access ons was done using non h erarch cal cluster ng method using the software Statistical Package for Agricultural Research (Spar1)

3 1 2 Storage pest study

All the selected access ons were evalua ed for the suscept b l ty to storage pests A tr al was conducted w th 150 treatments n the labora ory Each treatment was repl cated t v ce w tl 25 seeds pe epl cat on pe plates F ve seeds nfested v th *Callosob cl s* spec es vere added o eacl rea n n T e p p es ere ncubated n dark for furtl e

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ınfestatıon After two months of ıncubatıon observatıons on the number of seeds ınfested wıth the pest were recorded and expressed as percentage

3 1 3 Study of pollen morphology

Dıstınct varıants from each taxa were selected for palynologıcal study The mature flower buds about to open next day were collected from selected accessıons and fixed ın 70% ethyl alcohol Acetolysıs was carrıed out as per the method descrıbed by Naır (1970) The anthers taken out from the fixed buds were put ın dıstılled water They were crushed well and sıeved through a clean b t of muslın cloth ınto a centrıfuge tube and centrıfuged for two mınutes at 2500 rpm The supernatant solut on was dıscarded After addıng 2ml of 70 percent alcohol agaın centrıfuged for two m nutes at 2500 rpm Supernatant was dıscarded and 2ml of glacıal acetıc acıd was added and agaın cen rıfuged for two mınutes Supernatant was dıscarded and acetolysıs mıxture (9 parts acet c acıd 1 part concentrated sulphurıc acıd) was added and then kept ın a water bath at 80°C for two mınutes The supernatant vas dıscarded after coolıng To the bro vn coloured pollen sedıment at the bottom of tube 2 3 ml of acetıc ac d was added shaken vıgorously and centrıfuged for two mınutes at 2500 rpm The supernatant vas d scarded and d st lled water was added and ceı trıfuged for two mınutes The process was repeated 3-4 tımes to d scard all the excess acetıc acıd About 1 2 ml of 50 percent glycerıne was added and kept for 20 m nutes and tl en centrıfuged for 2 mınutes at 2500 rpm The supernatant vas dıscarded and the tubes were kept ups de down over the t ssue paper for 3 5 nınutes A p nch of glycerıne gel was d pped ın pollen sed ment and mounted on ı glass sl de The slıde was observed under Stereoscop c Zoo n M croscope w th photographıc a tachment for studyıng pollen morphology

3 2 Bıochemıcal characterısatıon

Dıstınct varıants were selected from each taxa for bıochemıcal evaluatıon Only one accessıon each was taken from those taxa havıng no dıstınct varıatıon Leaf samples were collected from 30 day old plants of selected accessıons Enzyme ısolatıon electrophoresıs and staınıng of enzymes were done usıng the method descrıbed by Patra and Mıshra (1979) One to two grams of tıssue from each accessıon was homogenızed ın 0 3 0 4 ml extractıon buffer solutıon wıth a pre chılled mortar and pestle at 4°C The samples were then transferred ın to pre chılled 1 5 ml polyethylene mıcro centrıfugatıon tubes kept on ıce These were centrıfuged at 15 000 rpm for 20 m nutes at 20°C The clear supernatant was collected and used for electrophoresıs Electrophoresıs was carrıed out at a constant current of 10 mA for first 30 m nutes and subsequently at 20 mA t ll the track ng dye mıgrated to the lower end of the gel The gel vas then staıned wıth the staınıng reagent specıfic for the partıcular enzyme system

Peroxıdase (POX) ısoenzyme vas detected usıng benzıd ne as the hydrogen donor The gel was ıncubated at 37°C n 1 percent hydrogen peroxıde m xed w th an equal volume of saturated solutıon of benz dıne prepared n 2 5 percent acetıc acıd t ll v s ble bands developed (approxımately 3 m nutes) The gels were r nsed ın chılled d stılled water and preserved n 7 percent acetıc acıd

Poly phenol ox dase (PPO) was detected by enzymatıc brown ng The gel was equıl brated for 30 m nutes 0 1 percent *p* phenylene dıamıne n 0 1M potassıum phosphate buffer (pH 7) follo ved by 10 nM ca echol n the same buffer The a ld t on of catechol was followed by a gentle shakıng whıch resulted ın the appearance of dark brown dıscrete proteın bands

The staıned gel was used for scorıng data The bands were scored vısually for theır presence (1) or absence (0) wıth enzyme The characterıstıc matrıx based on the scores was used for constructıon of dendrogram usıng NTSYS pc software versıon 2 1 (Rohlf 1992)

3 3 Molecular characterısatıon based on Inter Sequentıal Sımple Repeats (ISSR) markers

Dıstınct varıants from each taxa were selected for molecular characterısatıon also From those taxa havıng no dıstınct varıatıon only one accessıon each was taken Termınal leaf samples were collected from 30 day old plants of the selected accessıons The DNA was extracted followıng the cetyltrımethyl ammonıum bromıde (CTAB) method descrıbed by Nagarajan and Senthılkumar (2002) The leaf t ssue (2g) was frozen ın lıquıd nıtrogen and ground nto f ne powder The f ne powder was allowed to tha v ın the presence of 15 ml of pre heated CTAB extract on buffer contaın ng β mercaptoethanol ın polypropylene centrıfuge tubes and ıncubated for 45 mınutes at 65°C w th occasıonal mıxıng The tubes vere re noved from the water bath and allowed to cool at room temperature An equal volume of chloroform *so*amyl alcohol m xture (24 1) was added and mıxed well by nvers on for 15 m nutes and then centr fuged at 4000 rpm for 20 mınutes at room temperature The DNA was prec p tated usıng ıce cold *so*propanol and ıncubated at 20°C It vas then centrıfuged at 4000 rpm for 20 m nu es at room temperature to pellet the DNA and vasl ed w h 70% alcohol and a r drıed Dependıng upon the pellet s ze tl e DNA was d ssolved ?00 500 µl of rıs HCL EDTA (TE) buffe (pH 8) RNA contam a o vas ren oved by

RNase treatment and incubated at 37°C for 30 minutes Equal volume of chloroform *iso*amyl alcohol mixture (500 µl) was added and mixed thoroughly by repeated inversions Precipitation and pelleting of DNA was repeated once again and depending upon the size of the pellet DNA was d ssolved in 250 500 µl of TE (pH 8) and stored at 4°C

Agarose gel electrophoresis (0 8%) was performed to check the quality of DNA Two microlitre of DNA sample was dissolved in TE buffer and pipetted onto a paraf lm and mixed well with 3µl of load ng dye by pipetting up and down several t mes The contents were loaded nto the wells carefully with the help of a micropipette The gel was run at 90 volts till the tracking dye reached one third of the distance and bands were visualized and documented in gel documentation system (Alpha Imager 2200 Alpha Innotech Corp USA)

DNA was quant f ed by using spectrophotometer One µL of crude DNA was diluted to 1 mL deionized water The absorbance for all accession was measured at 260 nm An opt cal density (OD) of 1 0 corresponds to 40 µg / ml for double stranded DNA The quantity of DNA was determ ned as ad40/1000 µg/µl where a s the optical dens ty and d is the d lution factor

Based on the quant ficat on data DNA d lutions were made n TE buffer to a final concentration of 25ng/µL and stored n 20°C for ISSR analysis as per the procedure followed by Nagarajan and Senthilkumar 2002 A total of 10 ISSR pr mers were used for the analys s The pr mers used and their sequences are given n Table 7

Table 7 Details of pnmers used for ISSR analysis

Sl No	ISSR Pnmer	Sequence (5 3)
1	UBC 809	AGAGAGAGAGAGAGAGG
2	UBC 840	GAGAGAGAGAGAGAGAYT
3	UBC 841	GAGAGAGAGAGAGAGAYC
4	UBC 816	CACACACACACACACAT
5	UBC 856	ACACACACACACACACYA
6	UBC 810	AGAGAGAGAGAGAGAGT
7	UBC 812	GAGAGAGAGAGAGAGAA
8	UBC 842	GAGAGAGAGAGAGAGAYG
9	UBC 813	CTCTCTCTCTCTCTCTT
10	UBC 857	ACACACACACACACACYG

Y (C T)

The cocktail for the ampl f cat on was prepared as follows in 0 2ml PCR tubes

DNA (10 ng/µl)	2 00 µl
dNTPs (10 mM) (Bangalore Genei Ltd Ind a)	0 30 µl
Pnmer [University of Br t sh Columbia (UBC)]	2 00 µl
10X assay buffer	1 50 µl
Taq polymerase (0 3 units µL) (Bangalore Genei Ltd India)	0 15 µl
Sterile dist lled H_20	9 05 µl
Total	15 00 µl

The react on m xture was g ven a short sp n and was subjected to polymerase chain reaction (Eppendorf Master Cycler Inc) The thermal cyclers were programmed as follo vs

Profile 1 94°C for 5 mmutes Imtial denaturation

Profile 2 94°C for 1 mmute Denaturmg

Profile 3 55°C for 2 mmutes Annealmg

Profile 4 72°C for 2 mmutes Extension

Profile 5 72°C for 5 mmutes Fmal extension

Profile 6 4°C to hold the samples for mf mty

Profiles 2 3 and **4** were programmed to run for 45 cycles

Agarose gel electrophoresis (1 5%) was performed to separate the ampl fied products The gel was run at 100 volts for 3 hours and bands were visualized and documented m gel documentation system (Alpha Imager 2200 Alpha Innotech Corp USA)

The bands were scored v sually for their presence (1) or absence (0) with each primer As m 3 2 dendrogram was constructed based on the charactenst c matnx The species relat onship was explamed based on the dendrogram and compared w th that obta ned usmg morphological data and biochemical data

3 4 Companson of different clusterng patterns and development of statistical key for *Vigna* taxa

For each qualitative cluster the percentage of accessions of each taxa distnbuted mto vanous quant tat ve clusters were worked out to f nd out the relationship between qual tative and quant tat ve clustenng patterns Simılarly the homology between qualitat ve b ochemical and molecular clustenng patterns were also worked out

The weighted averages of various quantitative characters in different taxa were computed using the formula

$$\text{Weighted average} = \frac{\sum_{i}^{n} p_i x_i}{\sum_{i}^{n} p_i}$$

Where p_i is the percent accessions falling in quantitative cluster i, x_i the corresponding character mean based on the members falling in quantitative cluster i and n is the total number of quantitative clusters

The key quantitative characters for each taxa were identified as those which had a CV above 25 percent in all the respective quantitative clusters in which the accessions of the taxa were distributed Using these key quantitative characters a statistical key was developed for distinguishing the various taxa

3 5 Taxonomic key for identification of taxa of *Vigna*

A dichotomous key was developed considering the morphological biochemical and molecular characters for identifying the different taxa of *Vigna*

Results

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4 Results

The results of the three experiments conducted with 150 accessions of taxa of *Vigna* in the present investigation are given below

4 1 Morphological characterisation

The observations on 48 qualitative characters and the mean values of 24 quantitative characters recorded in 150 accessions of *Vigna* taxa are presented in Annexure 1 Based on the qualitative characters the 150 accessions evaluated were regrouped into 22 different taxa The number of accessions in each taxa along with sub genus and section are presented in Table 8 Among the 48 qualitative characters studied variability was observed in 23 characters and the results are presented in Table 9 From the table it can be seen that characters like type of seed germ nat on nature of attachment of primary leaves size of stipule shape of stipule presence of ligule shape of bracteole nature of pod attachment to peduncle curvature of pod shape of seed and shape of hilum varied with the taxa The type of germination and nature of attachment of primary leaves were epigeal and petiolate in *V tr lobata* *V i ngt ic lata* and n new *V g ia* spec es epigeal and sub sessile in *V khandale s s* *V m ngo* var *n m go* *V mi ngo* var *sylvestris* *V rad ata* var *adiata* *V ad ata* var *set losa* *V rad ata* var *si blobata* *V l ai i ai a* and *V s b a nan a ia* hypogeal and pet olate in *V aco t fol a* *V dalzell ana* *V arina* *V pilosa* *V glab esce is* *V st p lacea* *V tr erv a* var *bou i eae* *V t i e v a* var *tri ervia* *V i mbellata* var *i mbellata* and *V bellata* var *gracilis* and hypogeal and sub sess le in *V vex llata* The germination behav our observed n d fferent taxa of *I g a* are presented n Plate 1a to 1c The lob ng of term nal leaflet va ed f o u lobed o very deeply lobed in d fferent taxa of *I g a* as presented n Plate ? Orna ne tat o on leaf o ncl ded in the descr p or vas also observed

Table 8 Grouping of 150 taxa of *Vigna*

Sl No	Sub genus	Section	Taxa	No of accessions
1	*Ceratatropis*	*Angulares*	*V dalzelliana*	21
2			*V glabrescens*	1
3			*V trinervia* var *trinervia*	1
4			*V trinervia* var *bourneae*	19
5			*V umbellata* (Cultivated)	11
6			*V umbellata* var *gracilis*	4
7		*Ceratotropis*	*V haimana*	10
8			*V khandalensis*	1
9			*V mungo* var *mungo*	2
10			*V mungo* var *sylvestris*	22
11			*V radiata* var *radiata*	7
12			*V radiata* var *sublobata*	15
13			*V radiata* var *setulosa*	6
14			*V subramaniana*	3
15		*Acon itifoliae*	*V aconitifolia*	1
16			*V stipi lacea*	3
17			*V trilobata*	13
18	*Plectotrop s*	Plectotropis	*V vexillata*	4
19	*Vigna*	Catiang	*V unguiculata*	3
20			*V pilosa*	1
21			*V marina*	1
22			New *Vigna* species	1

Table 9 Variability in qualitative characters of different taxa of *Vigna*

Taxa	Type of seed germination	Shape of primary leaf	Nature of attachment of primary leaves	Lobing of terminal leaflet	Shape of terminal leaflet tip	Size of stipule	Shape of stipule	Presence of ligule
V. aconitifolia	Hypogeal	Lanceolate	Petiolate	Very deep lobed	Acute	Minute	Lanceolate	Small
V. dalzelliana	Hypogeal	Ovate lanceolate	Petiolate	Unlobed or very shallow lobed	Acute	Minute	Lanceolate	Very minute to small
V. glabrescens	Hypogeal	Ovate lanceolate	Petiolate	Unlobed	Rhombic	Large	Ovate	Very minute
V. hainiana	Epigeal	Ovate lanceolate	Sub sessile	Unlobed	Acute	Medium	Ovate	Small
V. khandalensis	Epigeal	Ovate lanceolate	Sub sessile	Shallow lobed	Acute	Minute	Ovate	Very minute
V. [illegible]	Hypogeal	Ovate lanceolate	Petiolate	Unlobed	Round	Minute	Lanceolate	Absent
V. mungo var. *mungo*	Epigeal	Ovate lanceolate	Sub sessile	Unlobed	Sub acute	Medium	Lanceolate	Small
V. mungo var. *sylvestris*	Epigeal	Ovate lanceolate	Sub sessile	Unlobed	Acute	Medium	Lanceolate	Small
V. pilosa	Hypogeal	Deltoid	Petiolate	Unlobed	Acute	Small	Lanceolate	Absent
V. radiata var. *radiata*	Epigeal	Ovate lanceolate	Sub sessile	Unlobed or intermediate lobed	Sub acute	Medium	Ovate	Small
V. radiata var. *sublobata*	Epigeal	Ovate lanceolate	Sub sessile	Unlobed or shallow lobed	Sub acute	Medium to large	Ovate	Small

Taxa	Type of seed germination	Shape of primary leaf	Nature of attachment of primary leaves	Lobing of term nal leaflet	Shape of term nal leaflet tip	Size of stipule	Shape of stipule	Presence of ligule
V ad ata var *set losa*	Ep geal	Ovate lanceolate	Sub sessile	Unlobed	Sub acute obtuse	Medium to large	Ovate	Small
V st pi lacea	Hypogeal	Cordate with cuneate tip	Petiolate	Shallow or deep lobed	Round rhomboid	Small	Ovate	Small
V s b a nan a a	Epigeal	Ovate	Sub sessile	Unlobed	Sub acute	Medium	Ovate	Small
V tr loba a	Epigeal	Cordate with cuneate t p	Petiolate	Intermediate or deep lobed	Round obtuse rhomboid	Large	Ovate	Small
V t ien a var *bo neae*	Hypogeal	Ovate	Pet olate	Unlobed or shallow lobed	Acute	Minute to medium	Ovate lanceolate	Very minute to small
V tr ie v a var *t ne v a*	Hypogeal	Ovate	Petiolate	Shallow lobed	Acute	Medium	Ovate lanceolate	Small
V i mbellata va *umbellata*	Hypogeal	Lanceolate	Pet olate	Shallow lobed	Acute	Minute	Ovate lanceolate	Small
V mbellata var *g ac l s*	Hypogeal	Cordate	Petiolate	Unlobed	Acute	Small	Ovate lanceolate	Small
V ngi culata	Epigeal	Ovate	Petiolate	Unlobed	Sub acute	Medium	Ovate lanceolate	Small
I ex llata	Hypogeal	Ovate lanceolate	Sub sess le	Unlobed	Acute	Minute	Ovate lanceolate	Absent
Nc v *I g ia* spec es	Ep geal	Ovate lanceolate	Pet olate	Unlobed	Acute	Medium	Ovate	Small

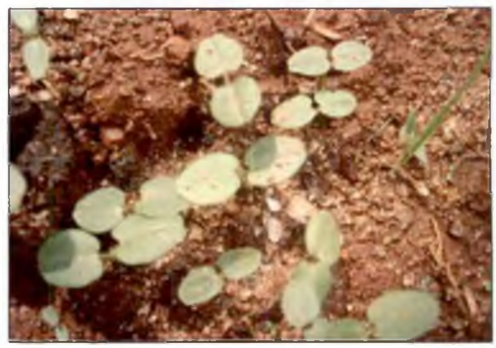
Taxa	Colour of flower	Colour of corolla	Shape of bracteole	Color of peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod
I acon t fol a	Yellow	Yellow	Ovate lanceolate	Green	Horizontal pendent	Intermediate green	Brown
V lalzell ana	Pale yellow to golden yellow	Yellow	Lanceolate	Green to purple	Pendent	Intermediate green	Tan to light brown
I glab esce s	Golden yellow	Yellow	Absent	Green	Horizontal	Dark green	Brown
I l a n a a	Yellow	Yellow	Lanceolate	Green to greenish purple	Horizontal	Intermediate to dark green	Straw
V l l a dale s s	Pale yellow	Yellow	Ovate lanceolate	Green	Horizontal pendent	Intermediate green	Brown
V na a	Pale yellow	Yellow	Absent	Green	Pendent	Light green	Brown
I go va *ngo*	Golden yellow	Yellow	Lanceolate	Greenish purple	Horizontal	Intermediate green	Black
V n ngo var *syl estr s*	Golden yellow	Yellow	Lanceolate	Green	Sub erect	Intermediate green	Black
V l losa	V olet	Violet	Absent	Green	Pendent	Intermediate green	Cream
I ad ata var *ad ata*	Greenish yellow to yellow	Greenish yellow to greenish purple-yellow	Ovate lanceolate	Green sh purple to purple	Horizontal	Intermediate to dark green	Tan to brown
I d v *blobata*	Green sh yellow to yellow	Yellow to greenish purple-yellow	Ovate lanceolate	Greenish purple	Horizontal pendent	Intermediate green	Tan

Taxa	Colour of flower	Colour of corolla	Shape of bracteole	Color of peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod
V ad ata var *setulosa*	Yellow to golden yellow	Yellow to Green with purple tinge	Ovate lanceolate	Green to greenish purple	Horizontal pendent	Intermediate to dark green	Tan
V st pı lacea	Yellow to golden yellow	Yellow	Ovate lanceolate	Green to greenish purple	Horizontal pendent	Light green	Straw with purple stripes
V sub a a ana	Green sh yellow	Greenish yellow	Lanceolate	Greenish purple	Horizontal pendent	Intermediate green	Tan
V t loba a	Yellow to golden yellow	Yellow	Lanceolate	Green	Pendent sub erect	Intermediate to dark green	Tan to brown
V ne a va *bo rneae*	Golden yellow	Yellow to green sh purple-yellow	Ovate lanceolate	Green	Horizontal	Light green	Tan to black
c vı *ıe v a*	Golden yellow	Yellow	Ovate lanceolate	Green	Horizontal	Light green	Brown and black
bellata var *mbellata*	Golden yellow	Yellow	Lanceolate	Gree ı	Pendent	Pale green	Tan
I bella a vı *grac l s*	Yellow to golden yellow	Yellow	Ovate lanceolate	Green	Pendent	Intermediate green	Tan
I gı c la a	V olet	Violet	Absent	Green	Erect	Intermediate green	Dark brown
I x ll	Violet	Violet	Lanceolate	Green	Horizontal	Intermediate green	Tan
New *V g a* species	Yellow	Yellow	Ovate lanceolate	Green	Horizontal pendent	Intermediate green	Tan

Taxa	Curvature of pod	Shape of pod beak	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	Shape of hilum
V aco tifol a	Straight	Pointed	Ellipt c	Intermed ate green	Present	Absent	Concave
V lal ell a a	Straight to curved	Pointed	Oblong	Greyish green mottled with black	Present	Intermediate heavy	Convex
V glab esce s	Straight	Blunt	Oblong	Black	Present	Absent	Concave
V ha i ana	Straight	Pointed	Ell ptic	Greyish mottled with black	Absent	Intermediate heavy	Convex
I l I a dalens s	Straight	Pointed	Oblong	Blackish brown	Absent	Absent	Plain
V n a a	Straight	Blunt	Round	Brown	Absent	Absent	Plain
V go var *ngo*	Stra ght	Blunt	Oblong	Black sh brown	Absent	Absent	Convex
go va *sylvest s*	Stra ght	Pointed	Round	Mottled blackish brown	Absent	Absent intermediate	Convex
losa	Stra ght	Pointed	Round	Brown	Absent	Absent	Concave
I d v *ad ata*	Stra ght	Po nted blunt	Recta igular	L ght green to intermediate green	Absent	Absent	Concave
V ad a a var s *blobata*	Straight	Pointed blunt	Oblong	Black sh brown	Absent	Absent	Concave

Taxa	Curvature of pod	Shape of pod beak	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	Shape of hilum
V ad ata var *seti losa*	Straight	Pointed blunt	Rectangular	Black	Absent	Absent	Plain
I st p lacea	Stra ght	Blunt	Oblong	Cream mottled with black	Absent	Intermediate	Convex
V s bra a a a	Stra ght	Blunt	Oblong	Black mottled grey	Absent	Absent	Plain
V lobata	Stra ght	Blunt	Oblong	Black sh grey	Absent	Slight	Concave
I e var *bo eac*	Straight	Blunt	Rectangular	Black blackish grey	Absent	Absent slight	Plain
I e a var *t ne a*	Stra ght	Blunt	Oblong	Black	Absent	Absent	Plain
I ll a var *bellata*	Slightly curved	Pointed	Ell ptic	Green to black	Present	Absent ntermediate	Convex
I bella a var *grac l s*	Curved	Blunt	Ell ptic	Black mottled black	Present	Intermediate heavy	Concave
V ngu c lata	Straight	Pointed	K dney shaped	Cream chocalate brown	Absent	Absent	Concave
V vex llata	Straight	Pointed	K dney shaped	Blackish brown	Present	Absent	Concave
New *V g a* species	Straight	Po nted	Oblong	Mottled black	Absent	Intermediate	Convex

V.aconitifolia
Hypogeal and petiolate



V.trilobata
Epigeal and petiolate

V.stipulacea
Hypogeal and petiolate

V. vexillata
Hypogeal and sub-sessile

Plate 1a. Germination behaviour in *Vigna* taxa

V.hainiana

V.khandalensis

V.mungo var.*mungo*

V.mungo var.*sylvestris*

V.radiata var.*radiata*

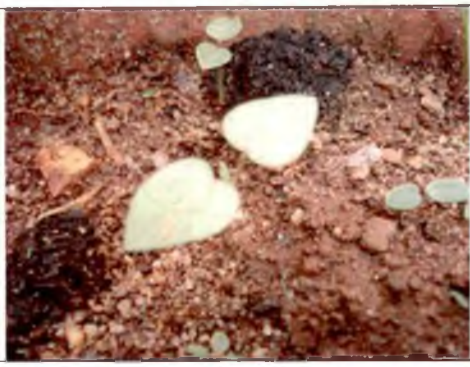
V.radiata var.*sublobata*

V.radiata var.*setulosa*

V.subramaniana

Epigeal and sub-sessile

Plate 1b. Germination behaviour in *Vigna* taxa



V. dalzelliana

V. glabrescens

V. trinervia var. *trinervia*

V. trinervia var. *bourneae*

V. umbellata var.*umbellata* (Cultivated)

V. umbellata var. *gracilis*

V.aconitifolia

V.stipulacea

Hypogeal and petiolate

Plate 1c. Germination behaviour in *Vigna* taxa

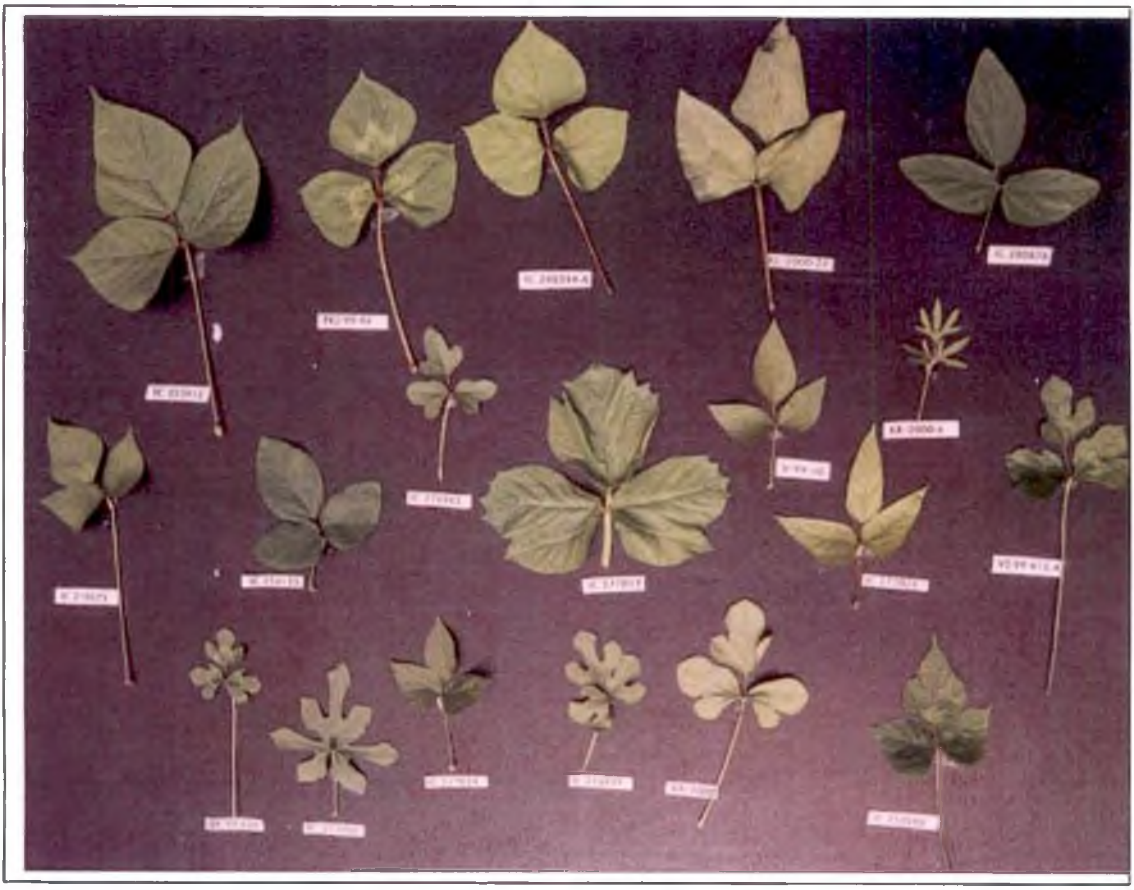


Plate 2. Variability in lobing of terminal leaflet in different taxa of *Vigna*

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in all the accessions Ornamentation was present in *V stipi lacea V trinervia* var *bourneae* and *V dalzelliana* and was absent in all the other taxa The colour of ornamentation was either white as observed in *V stipi lacea* and *V trinervia* var *boi rneae* or green as in *V dalzelliana* The variability in ornamentat on on the leaves of *V trilobata* and *V stipulacea* is presented n Plate 3a Plate 3b depicts the variability in ornamentation of *V trinervia* var *trinerv ia* and *V trinervia* var *boi rneae* The stipule shape was lanceolate n *V aconitifolia I dalzelliana V mar na V mi ngo* var *n i ngo V mungo* var *sylvestris* and *V pilosa* ovate lanceolate in *V tri iervia* var *bourneae V tr nervia* var *tri ervia V i mbellata* var *i mbellata V u bellata* var *g acil s V ungi ci lata* and *V vexillata* ovate in *V haimiana V khandalensis V radiata V radiata* var *sublobata V adiata* var *set losa V stipi lacea V s bi amaniana V trilobata* and in the new species The variab lity in stipule size and shape of d fferent *Vig ia* taxa s depicted n Plate 4 Bracteole was absent n *V u gi ici lata V pilosa* and *V marina* The hilum shape was concave in *V aco i t folia V p losa V adiata V radiata* var *si blobata V trilobata V i bellata* var *grac l s V i g ci lata V exillata* plain in *V kl a dale is s V n ari a V ad ata* var *set losa V s b a a ai V t e v a* var *bo i eae* and *V t ie via* var *tri erv a* and convex in *V dalzell ana V ha n ana V mi ngo* var *mi ngo V n i ngo* var *sylvest s V st p lacea V n bellata* var *i mbellata* and in the new species Corolla was violet n *V ng c lata V vex llata* and *V pilosa* and yellow or shades of yellow in all the other taxa

The summary stat stics *viz* range m nimum max mum mean standard dev at on standard error and coeff c en of var at on of the quant tat ve characters are presented n Table 10 From Table 10 t can be seen hat all characters exh bited w de range of variabil ty Variab l y of more l a 90 p c cen ob erved n cha act s l ke seed y eld plant (218 11)

Plate 3a. Variability in ornamentation of leaf in *Vigna* taxa

1, 2, 3 – *V.stipulacea*; others – *V.trilobata*

Plate 3b. Variability in ornamentation of leaf in *Vigna* taxa

1 – *V. trinervia* var. *trinervia*
2, 3, 4 – *V. trinervia* var. *bourneae*

Plate 4. Variability in stipule size and shape in different taxa of *Vigna*

1. *V.stipulacea* (IC202559)
2. *V.trinervia* var.*bourneae* (IC247407)
3. *V.umbellata* var.*gracilis* (IC251370)
4. *V.glabrescens* (IC251372)
5. *V.trilobata* (IC251431)
6. *V.umbellata* (IC251442)
7. *V.radiata* var.*sublobata* (IC248344A)
8. *V.vexillata* (IC406507)
9. *V.mungo* var.*sylvestris* (IC277014)
10. *V.unguiculata* (IC298665)
11. *V.radiata* var.*sublobata* (IC322206)
12. *V.trinervia* var.*trinervia* (IC337486)
13. *V.dalzelliana* (IC203864)
14. *V.mungo* var.*mungo* (IC331447)
15. *V.hainiana* (IC331448)
16. *V.stipulacea* (IC324552)
17. *V.aconitifolia* (IC417347)
18. *V.mungo* var.*sylvestris* (IC539798)
19. *V.mungo* var.*sylvestris* (IC539800)
20. *V.trilobata* (IC541215)
21. *V.marina* (IC539828)

Table 10 Variability parameters in 150 accessions of taxa of *Vigna*

Sl No	Characters	Range	Minimum	Maximum	Mean	SE	SD	CV (%)
1	Days to emergence	17 00	2 00	19 00	7 75	0 1651	2 8594	36 91
2	Primary leaf length (cm)	6 33	0 90	7 23	2 86	0 0796	1 3795	48 24
3	Primary leaf width (cm)	3 80	0 60	4 40	1 59	0 0286	0 4945	31 12
4	Terminal petiolule length (cm)	3 43	0 80	4 23	2 16	0 0357	0 6185	28 58
5	No of lobes in terminal leaflet	5 00	0 00	5 00	1 53	0 0880	1 5242	99 41
6	Terminal leaflet length (cm)	13 23	2 10	15 33	8 30	0 1438	2 4898	30 00
7	Terminal leaflet w dth (cm)	11 24	1 93	13 17	6 49	0 1083	1 8762	28 92
8	Petiole length (cm)	23 33	3 50	26 83	9 60	0 2354	4 0774	42 48
9	No of primary branches	6 00	0 00	6 00	3 13	0 0488	0 8444	27 01
10	Days to flowering	135 00	33 00	168 00	74 17	1 8777	32 5235	43 85
11	Size of flower bud (l xb)	12 28	0 30	12 58	1 96	0 1032	1 7872	91 38
12	Size of bracteole (mm)	3 00	0 00	3 00	1 95	0 0527	0 9132	46 75
13	No of flowers/raceme	14 00	1 00	15 00	5 74	0 1207	2 0897	36 41
14	Keel pocket length (mm)	4 00	0 00	4 00	2 83	0 0572	0 9910	34 98
15	Peduncle length (cm)	36 43	3 40	39 83	13 71	0 3255	5 6375	41 12
16	No of pods/ peduncle	6 00	1 00	7 00	3 22	0 0508	0 8799	27 33
17	Days to first pod maturity	136 00	48 00	184 00	87 12	1 5814	27 3911	31 44
18	Pod length (cm)	10 50	1 96	12 46	5 06	0 1124	1 9462	38 44
19	No of seeds pod	18 00	1 20	19 20	10 19	0 1481	2 5646	25 16
20	100 seed weight (g)	10 89	0 45	11 34	1 77	0 0957	1 6572	93 80
21	Seed length (mm)	6 79	2 03	8 82	3 62	0 0759	1 3150	36 32
22	Seed width (mm)	4 33	1 52	5 85	2 68	0 0404	0 6989	26 05
23	Hilum length (mm)	3 84	0 20	4 04	1 59	0 0409	0 7076	44 41
24	Seed yield plant (g)	1090 30	0 20	1090 50	58 98	7 4265	128 6302	218 11

number of lobes ın termınal leaflet (99 41) 100 seed weıght (93 80) and sıze of flower bud (91 38) The characters whıch showed varıabıl ty of less than 30 percent were termınal leaflet wıdth (28 92) termınal petıolule length (28 58) number of pods/peduncle (27 33) number of prımary branches (27 01) seed wıdth (26 05) and number of seeds/pod (25 16) The keel pocket was present ın all taxa except *V ı nguıculata* *V marına* and *V pılosa* The length of keel pocket varıed from taxa to taxa Plate 5 depıcts the varıabılıty ın keel pocket length ın dıfferent *Vıgna* taxa The keel pocket was long ın *V m ngo* var.*syl estrıs* and *V ı n bellata* var *ı mbellata* mınute ın *V haınıana* *V trılobata* and *V stıpulacea* and short or medıum short ın all the other taxa

4 1 1 Cluster analysıs based on qualıtatıve characters

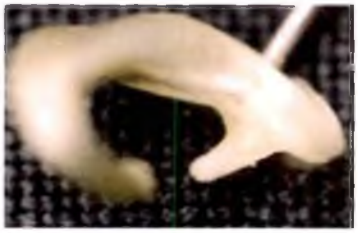
Agglomeratıve hıerarchıcal clusterıng was performed based on the Jaccard s sımılarıty coeff cıent utılızıng the UPGMA method for 47 qual tatıve characters and the dendrogram obtaıned ıs presented ın Fıgure 1 The 150 *Vıg ıa* taxa evaluated could be grouped ınto 10 clusters at 60 percent s mılar ty level The lıst of 10 clusters obta ned along w th the accessıo s ncluded n each cluster ıs presented ın Table 11 All accessıons belongıng to four d fferent taxa *v z* *V radıata* var *radıata* *V ad ata* var *s blobata* *V ad ata* var *set losa* and *V s b a ı a ıana* were grouped ın cluster I Cluster II ıncluded access ons belongıng to two taxa *v z* *V trıner a* var *boı rneae* and *V trıne vıa* var *trınerv a* All accessıons of *V haınıana* *V mı ngo* var *sylvestr s* *V mı ngo* var *mı ngo* and the new specıes were fall ng n cluster III The only access on of *V kha dalens s* fell n cluster IV Access ons belong ng to *V lobata* and *I st p lacea* were ıncluded ın cluster V One accessıon of *V gl b esce s* rema ned cluster VI Clus er VII ncluded access ons belongıng o *V d l ell a I bell* ar *bella* a d *I bell* a g *ac l* One access on of

V.hainiana

V.radiata var.*setulosa*

V.mungo var.*sylvestris*

V.radiata var.*sublobata*



V.radiata var.*radiata*

V.subramaniana

V. umbellata var.*umbellata*

V.unguiculata

V.trilobata

Plate 5. Variability in keel pocket in different taxa of *Vigna*

Table 11 Clusterıng pattern based on qualıtatıve characters

Sl No	Cluster No	No of accessıons	Code of accessıons	Taxa
1	I	31	Vrs1 Vrs2 Vrs3 Vrs4 Vrs5 Vrs6 Vrs7 Vrs8 Vrs9 Vrs10 Vrs11 Vrs12 Vrs13 Vrs14 Vrs15	*V radıata* var *sublobata*
			Vse1 Vse2 Vse3 Vse4 Vse5 Vse6	*V radıata* var *setulosa*
			Vsb1 Vsb2 Vsb3	*V subramanıana*
			Vr1 Vr2 Vr3 Vr4 Vr5 Vr6 Vr7	*V radıata* var *radıata*
2	II	20	Vtb1 Vtb2 Vtb3 Vtb4 Vtb5 Vtb6 Vtb7 Vtb8 Vtb9 Vtb10 Vtb11 Vtb12 Vtb13 Vtb14 Vtb15 Vtb16 Vtb17 Vtb18 Vtb19	*V trınervıa* var *bourneae*
			Vtt	*V trınervıa* var *tr nerv a*
3	III	36	Vh1 Vh2 Vh3 Vh4 Vh5 Vh6 Vh7 Vh8 Vh9 Vh10	*V haın ana*
			Vms1 Vms2 Vms3 Vms4 Vms5 Vms6 Vms7 Vms8 Vms9 Vms10 Vms11 Vms12 Vms13 Vms14 Vms15 Vms16 Vms17 Vms18 Vms19 Vms20 Vms21 Vms22	*V mı ngo* var *sylvestr s*
			Vmu1 Vmu2	*V mı ngo* var *mungo*
			V	New *V gna* specıes
			Vd16	*V dalzellıa a*
4	IV	1	Vk	*V khandalens s*
5	V	16	Vst1 Vst2 Vst3	*V st pulacea*
			Vt1 Vt2 Vt3 Vt4 Vt5 Vt6 Vt7 Vt8 Vt9 Vt10 Vt11 Vt12 Vt13	*V tr lobata*
6	VI	1	Vg	*V glabrescei s*
7	VII	35	Vd1 Vd2 Vd3 Vd4 Vd5 Vd6 Vd7 Vd8 Vd9 Vd10 Vd11 Vd12 Vd13 Vd14 Vd15 Vd17 Vd18 Vd19 Vd20 Vd21	*V dalzell ana*
			Vu1 Vu2 Vu3 Vu4 Vu5 Vu6 Vu7 Vu8 Vu9 Vu10 Vu11	*V n bellata* var *ı n bellata*
			Vug1 Vug2 Vug3 Vug4	*V mbellata* var *grac l s*
8	VIII	1	Va	*V acon t folıa*
9	IX	7	Vv1 Vv2 Vv3 Vv4	*V ex llata*
			Vun1 Vun2 Vun3	*V g c lata*
10	X	1	Vma	*V marına*
		1	Vp	*V p losa*

V aconitifolia remained separately as cluster VIII Accessions of *V unguiculata* and *V vexillata* were grouped in cluster IX and of *V marina* and *V pilosa* in cluster X From the clustering pattern it could be seen that all accessions belonging to a single taxa were grouped together in the same cluster In the case of *V dalzelliana* all accessions fell in cluster VII except one (Vd16) which fell in cluster III

4 1 2 Cluster analysis based on quantitative characters

Cluster analysis was performed using all quantitative characters except days to emergence number of lobes in terminal leaflet number of primary branches and days to first pod maturity as these characters could not be accommodated in the SPAR1 programme Five clusters were obtained and accessions included in each cluster are presented in Table 12 The intra and inter cluster distances are presented in Table 13 The distances between each cluster centroids are represented in Figure 2 The maximum distance was between cluster II and IV (8 758) and the minimum was between cluster I and II (2 515)

Table 13 Intra and inter cluster distances between clusters

Cluster	I	II	III	IV	V
I	2 505				
II	2 515	2 985			
III	3 209	4 227	3 188		
IV	8 150	8 758	6 479	4 917	
V	3 213	4 516	3 205	6 754	3 512

Table 12 Clustering pattern based on quantitative characters

Sl No	Cluster No	No of accessions	Code of accessions	Taxa
1	I	51	Vd2 Vd3 Vd4 Vd5 Vd6 Vd7 Vd8 Vd9 Vd10 Vd11 Vd12 Vd13 Vd15 Vd16 Vd17 Vd18 Vd19 Vd20	*V dalzell ana*
			Vms20	*Vigna mungo var sylvestris*
			Vr7	*V radiata* var *radiata*
			Vrs1 Vrs2 Vrs3 Vrs4 Vrs5 Vrs6 Vrs7 Vrs8 Vrs9 Vrs10 Vrs12 Vrs13 Vrs14	*V radiata* var *sublobata*
			Vse5	*V radiata* var *setulosa*
			Vt1 Vt2 Vt3 Vt4 Vt5 Vt6 Vt7 Vt9 Vt10 Vt11 Vt12 Vt13	*V trilobata*
			Vtb12	*V trinervia* var *bourneae*
			Vug1 Vug2 Vug3 Vug4	*V umbellata* var *gracil s*
2	II	18	V	New *Vigi a* species
			Va	*V aconitifolia*
			Vd14	*V dalzell ana*
			Vh1 Vh2 Vh3 Vh4 Vh5 Vh6 Vh7 Vh8 Vh9 Vh10	*V ha nana*
			Vma	*V marina*
			Vst1 Vst2 Vst3	*V st pi lacea*
			Vt8	*V tr lobata*
3	III	38	Vr1 Vr2 Vr3 Vr4 Vr5 Vr6	*V rad ata* var *radiata*
			Vmu1	*V mi ngo* var *m ngo*
			Vms1 Vms2 Vms3 Vms4 Vms5 Vms6 Vms7 Vms8 Vms9 Vms10 Vms11 Vms12 Vms13 Vms14 Vms15 Vms16 Vms17 Vms18 Vms19 Vms21 Vms22	*V mungo* var *sylvestr s*
			Vrs11 Vrs15	*V rad ata* var *s blobata*
			Vse1 Vse2 Vse3 Vse4 Vse6	*V rad ata* var *setulosa*
			Vsb1 Vsb2 Vsb3	*V s bramaniana*
4	IV	18	Vg	*V glabrescens*
			Vk	*V kl andalens s*
			Vmu2	*V mungo* var *m ngo*
			Vp	*V p losa*
			Vu1 Vu2 Vu3 Vu4 Vu5 Vu6 Vu7 Vu8 Vu9 Vu10 Vu11	*V mbellata* var *umbellata*
			Vun1 Vun2 Vun3	*V guic lata*
5	V	25	Vtb1 Vtb2 Vtb3 Vtb4 Vtb5 Vtb6 Vtb7 Vtb8 Vtb9 Vtb10 Vtb11 Vtb13 Vtb14 Vtb15 Vtb16 Vtb17 Vtb18 Vtb19	*V tr nerv a* var *bo rneae*
			Vtt	*V tr en a* var *tri en a*
			Vd1 Vd21	*V dalzell ana*
			V 1 Vv2 V 3 V 4	*V vex llata*

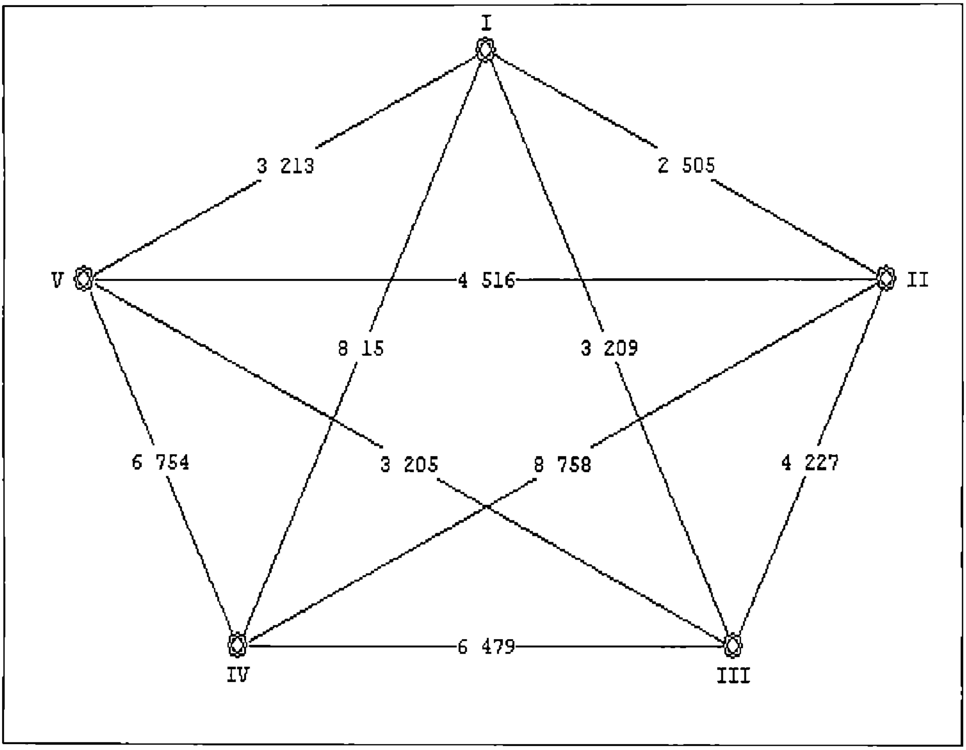


Fig 2 Cluster diagram showing cluster distances

4 1 3 Storage pest study

The percent of storage pest infestation recorded in 150 accessions of taxa of *Vigna* is presented in Table 14 The table shows that the infestation ranged from 0 100 percent Zero percent infestation was observed in 55 accessions belonging to different taxa except *V aconitifolia* *V subramaniana* and the new species Hundred percent infestation was observed in two accessions each in *V umbellata* var *umbellata* and *V unguiculata* A histogram representing the frequency distribution of 150 accessions on the basis of infestation level of storage pest is presented in Figure 3 The figure showed that 79 accessions had no infestation or less than 10% infestation by storage pest

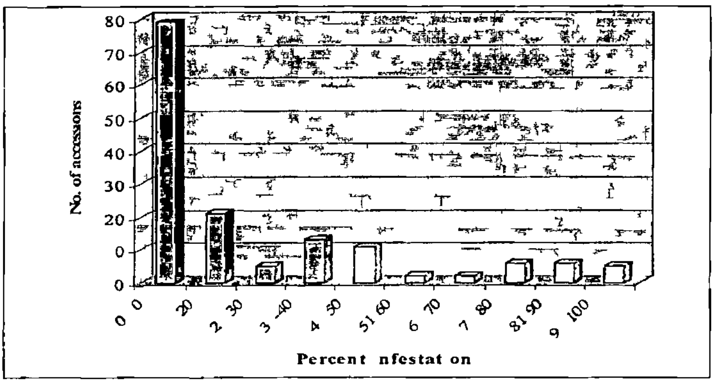


Fig 3 Frequency distribution for storage pest infestation

4 1 4 Study of pollen morphology

The pollen morphology of the selected accessions from 18 taxa of *Vigna* is presented in Table 15 and Plate 6a and 6b The flower buds and the pollen grains from the 4 taxa namely *V aconitifolia* *V minima* *V mungo* var *mungo* and *V subramaniana* were insufficient and hence could not be included in the study The study revealed that the pollen grains of all

Table 14 Storage pest ınfestatıon ın dıfferent taxa of *Vıg ıa*

Sl No	TCR No	Code for taxa	Taxa	IC Number	Mean	Percent of ınfestatıon
1	268	V	New *Vıg ıa* specıes	277045	4 5	18 0
2	350	Va	*V aconıt folıa*	417347	18 5	74 0
3	9	Vd1	*V dalzellıana*	247408	0 0	0 0
4	10	Vd2	*V dalzellıana*	203864	0 0	0 0
5	12	Vd3	*V dalzellıana*	210555	2 0	8 0
6	13	Vd4	*V dalzellıana*	210556	0 0	0 0
7	106	Vd5	*V dalzellıana*	210559	0 0	0 0
8	126	Vd6	*V dalzellıana*	210579	2 5	10 0
9	143	Vd7	*V dalzellıana*	248168	4 0	16 0
10	144	Vd8	*V dalzellıana*	248195	4 5	18 0
11	147	Vd9	*V dalzellıana*	248261	0 0	0 0
12	163	Vd10	*V dalzellıana*	248346	0 0	0 0
13	199	Vd11	*V dalzellıana*	336206	3 5	14 0
14	214	Vd12	*V dalzellıana*	253961	2 5	10 0
15	233	Vd13	*V dalzellıana*	253913	0 0	0 0
16	234	Vd14	*V dalzellıana*	253911	0 0	0 0
17	258	Vd15	*V dalzellıana*	277025	0 0	0 0
18	274	Vd16	*V dalzell ana*	277060	0 0	0 0
19	387	Vd17	*V dalzellıana*	539795	2 0	8 0
20	388	Vd18	*V dalzellıana*	539796	0 0	0 0
21	398	Vd19	*V dalzellıana*	539806	4 5	18 0
22	401	Vd20	*V dalzellıana*	550577	1 0	4 0
23	407	Vd21	*V dalzellıana*	541388	2 5	10 0
24	20	Vg	*V glaberescens*	251372	0 0	0 0
25	24	Vh1	*V ha ı ana*	251376	0 0	0 0
26	26	Vh2	*V haımana*	251378	0 0	0 0
27	29	Vh3	*V l aımana*	251381	0 0	0 0
28	207	Vh4	*V haımana*	349905	3 5	14 0
29	244	Vh5	*V ha ı ana*	276985	0 0	0 0
30	247	Vh6	*V haın ana*	276999	4 0	16 0
31	249	Vh7	*V haımana*	277007	0 0	0 0
32	307	Vh8	*V ha ı ana*	331438	0 0	0 0
33	314	Vh9	*V haın ana*	331448	0 0	0 0
34	323	Vh10	*V l aı ıana*	331460	1 5	6 0
35	165	Vk	*V khandale ıs s*	406504	0 0	0 0
36	405	Vma	*V na na*	539828	0 0	0 0
37	310	Vmu1	*V go* var *n ngo*	331441	0 0	0 0
38	313	Vmu2	*V ngo* var *n go*	ͻ31447	20 5	82 0
39	155	Vn s1	*V n go* var *syl es s*	248?94	11 0	44 0
40	157	Vms?	*I go* v1r *s l est s*	248326	1 0	4 0
41	158	Vms3	*I go* var *syl est s*	?48331	2 0	8 0
4?	160	Vms4	*I go* v r *sȝl es r s*	?48343	0 0	0 0

Sl No	TCR No	Code for taxa	Taxa	IC Number	Mean	Percent of infestation
43	171	Vms5	*V nu go* var *syl estı ıs*	256135	0 0	0 0
44	230	Vms6	*V mungo* var *syl estrıs*	253907	0 0	0 0
45	254	Vms7	*V mungo* var *sylvestrıs*	277014	9 0	36 0
46	256	Vms8	*V mungo* var *sylvestrıs*	277021	4 0	16 0
47	259	Vms9	*V mungo* var *sylvestrıs*	277026	9 0	36 0
48	260	Vms10	*V mungo* var *sylvestrıs*	277031	4 5	18 0
49	262	Vms11	*V mungo* var *sylvestrıs*	277036	0 0	0 0
50	265	Vms12	*V mungo* var *sylvestrıs*	277039	4 5	18 0
51	266	Vms13	*V mungo* var *sylvestrıs*	277041	11 0	44 0
52	267	Vms14	*V mungo* var *sylvestrıs*	277044	16 5	66 0
53	270	Vms15	*V mungo* var *sylvestrıs*	277053	0 0	0 0
54	271	Vms16	*V mungo* var *sylvestrıs*	277055	1 5	6 0
55	272	Vms17	*V mı ngo* var *sylvestrıs*	277057	11 5	46 0
56	275	Vms18	*V mungo* var.*sylvestrıs*	277061	3 5	14 0
57	276	Vms19	*V mungo* var *sylvestrıs*	277084	0 0	0 0
58	390	Vms20	*V mungo* var *sylvestrıs*	539798	7 0	28 0
59	392	Vms21	*V mungo* var *sylvestrıs*	539800	4 5	18 0
60	393	Vms22	*V mungo* var *syl estr s*	539801	0 0	0 0
61	410	Vp	*V p losa*	541389	0 0	0 0
62	60	Vr1	*V rad ata* var *rad ata*	251412	10 5	42 0
63	61	Vr2	*V rad ata* var *ı ad ata*	251413	12 5	50 0
64	62	Vr3	*V radıata* var *ad ata*	251414	19 0	76 0
65	70	Vr4	*V radıata* var *ı ad ata*	251422	0 0	0 0
66	72	Vr5	*V radıata* var *rad ata*	251424	9 0	36 0
67	74	Vr6	*V radıata* var *rad ata*	251426	0 0	0 0
68	188	Vr7	*V radıata* var *adıata*	349699	0 0	0 0
69	1	Vrs1	*V rad ata* var *s blobata*	202538	11 0	44 0
70	3	Vrs2	*V radıata* var *sublobata*	202580	0 5	2 0
71	5	Vrs3	*V radıata* var *s blobata*	202643	1 0	4 0
72	7	Vrs4	*V radıata* var *sı blobata*	247406	9 5	38 0
73	11	Vrs5	*V radıata* var *s blobata*	210554	7 0	28 0
74	66	Vrs6	*V rad ata* var *sı blobata*	251418	1 5	6 0
75	?78	Vrs7	*V rad ata* var *sı blobata*	281164	0 0	0 0
76	279	Vrs8	*V rad ata* var *sı blobata*	281165	9 0	36 0
77	297	Vrs9	*V rad ata* var *s blobata*	324496	0 0	0 0
78	300	Vrs10	*V radıata* var *s blobata*	322306	0 0	0 0
79	301	Vrs11	*V rad ata* var *s blobata*	351407	0 0	0 0
80	321	Vrs12	*I ad ata* var *s blobata*	331457	0 5	2 0
81	397	Vrs13	*V rad ata* var *sı blobata*	539805	3 5	14 0
82	400	Vrs14	*I ad a a* var *s blobata*	550576	0 5	2 0
83	161A	Vrs15	*V a l a a* vır *s blob a*	248344A	9 5	38 0
84	67	Vse1	*V ad ata* var *se losa*	?51419	20 5	82 0
85	68	Vse2	*I rad ata* var *set losa*	251420	9 5	38 0
86	69	Vse3	*I a l at* va *se losa*	51421	9 0	36 0

Sl No	TCR No	Code for taxa	Taxa	IC Number	Mean	Percent of infestation
87	71	Vse4	*V ad ata* var *setulosa*	251423	11 0	44 0
88	141	Vse5	*V ı adıata* var *setulosa*	351404	0 0	0 0
89	273	Vse6	*V radıata* var *setulosa*	277058	0 5	2 0
90	2	Vst1	*V stıpulaceae*	202559	3 5	14 0
91	215	Vst2	*V stıpulaceae*	256259	20 5	82 0
92	303	Vst3	*V stıpulaceae*	324552	1 0	4 0
93	238	Vsb1	*V subramanıana*	253920	22 5	90 0
94	240	Vsb2	*V subramanıana*	253926	20 0	80 0
95	241	Vsb3	*V subramanıana*	253930	19 5	78 0
96	83	Vt1	*V trılobata*	251435	1 0	4 0
97	84	Vt2	*V trılobata*	251436	5 0	20 0
98	86	Vt3	*V trılobata*	251438	8 5	34 0
99	192	Vt4	*V trılobata*	349701	5 5	22 0
100	243	Vt5	*V trılobata*	276983	0 0	0 0
101	295	Vt6	*V trılobata*	351406	0 5	2 0
102	305	Vt7	*V trılobata*	331436	17 5	70 0
103	306	Vt8	*V trılobata*	331437	0 0	0 0
104	318	Vt9	*V trılobata*	331453	0 0	0 0
105	319	Vt10	*V tı ılobata*	331454	4 0	16 0
106	320	Vt11	*V tr lobata*	331456	3 0	12 0
107	402	Vt12	*V tr lobata*	541215	12 5	50 0
108	403	Vt13	*V tr lobata*	541211	0 0	0 0
109	8	Vtb1	*V trıne ·v a* var *boı neae*	247407	0 0	0 0
110	121	Vtb2	*V tr nervıa* var *bourneae*	210574	3 5	14 0
111	142	Vtb3	*V trı e ·v a* var *boı ıneae*	264289	19 0	76 0
112	156	Vtb4	*V tr nerv a* var *boı rneae*	248296	6 5	26 0
113	164	Vtb5	*V t nen a* var *boı ı eae*	?49023	9 0	36 0
114	174	Vtb6	*V trıne ·v a* var *boı ıneae*	406509	1 5	6 0
115	176	Vtb7	*V tr nen a* var *bouı neae*	406510	2 5	10 0
116	189	Vtb8	*V tr nen a* var *bourneae*	349700	5 0	20 0
117	195	Vtb9	*V t enıa* var *boı rneae*	349704	1 0	4 0
118	206	Vtb10	*V tr nervıa* var *boı rneae*	349885	0 5	2 0
119	277	Vtb11	*V tr ıerv a* var *bo rneae*	281163	3 5	14 0
120	290	Vtb12	*V tr ne ·ı a* var *boı rı eae*	280784	20 5	82 0
121	311	Vtb13	*V r nen a* var *bourneae*	331442	0 0	0 0
122	342	Vtb14	*V tr ne ·ı a* var *bo rneae*	372379	8 5	34 0
123	345	Vtb15	*V t e ·ı a* var *boı neae*	372406	9 0	36 0
124	348	Vtb16	*V t ne ·ı a* var *bo neae*	333605	11 0	44 0
125	384	Vtb17	*V t ne a* var *bo r eae*	539792	3 5	14 0
126	385	\ tb18	*V t e ·ı a* var *boı neae*	539793	0 0	0 0
127	399	Vtb19	*V e a* var *bo eae*	550575	0 0	0 0
128	302	Vtt	*I t nen a* var *t e ·ı a*	337486	0 0	0 0
129	87	Vu1	*V g a bellata va bellat*	251439	0 0	0 0
130	88	Vu2	*V g a bellata a bella*	?51440	15 0	60 0

Sl No	TCR No	Code for taxa	Taxa	IC Number	Mean	Percent of infestation
131	89	Vu3	*Vigna umbellata var umbellata*	251441	0 0	0 0
132	90	Vu4	*Vigna umbellata var umbellata*	251442	25 0	100 0
133	91	Vu5	*Vigna umbellata var umbellata*	251443	25 0	100 0
134	92	Vu6	*Vigna umbellata var umbellata*	251444	0 0	0 0
135	93	Vu7	*Vigna umbellata var umbellata*	251445	0 0	0 0
136	94	Vu8	*Vigna umbellata var umbellata*	251446	22 0	88 0
137	95	Vu9	*Vigna umbellata var umbellata*	251447	12 5	50 0
138	204	Vu10	*Vigna umbellata var umbellata*	349904	23 5	94 0
139	298	Vu11	*Vigna umbellata var umbellata*	324483	0 0	0 0
140	18	Vug1	*Vigna umbellata* var *gracilis*	251370	0 0	0 0
141	330	Vug2	*Vigna umbellata* var *gracilis*	331618	5 5	22 0
142	331	Vug3	*Vigna umbellata* var *gracilis*	331621	1 0	4 0
143	334	Vug4	*Vigna umbellata* var *gracilis*	331624	0 0	0 0
144	208	Vun1	*Vigna unguiculata*	349906	19 0	76 0
145	284	Vun2	*Vigna unguiculata*	298665	25 0	100 0
146	308	Vun3	*Vigna unguiculata*	331439	25 0	100 0
147	161	Vv1	*Vigna vexillata*	248344	10 5	42 0
148	162	Vv2	*Vigna vexillata*	248345	0 0	0 0
149	169	Vv3	*Vigna vexillata*	406507	13 0	52 0
150	217	Vv4	*Vigna vexillata*	349723	9 0	36 0
Mean						21 8
SD						28 5
SE						2 3
CV (%)						130 7

Table 15 Pollen morphology of dıfferent taxa of *Vıgna*

Taxa	IC Number	Length (mμ)	Wıdth (mμ)	Exıne thıck ness (mμ)	Shape	Sculpturıng	Exıne spınes
New *Vıgna* specıes	277045	0 042	0 043	0 005	Cırcular	Mıcro retıculate	Mınute
V dalzellıana	210555	0 043	0 042	0 005	Cırcular	Mıcro retıculate	Mınute
V glaberescens	251372	0 055	0 057	0 005	Cırcular	Retıculate	Mınute
V haınıana	331448	0 036	0 037	0 004	Cırcular	Mıcro retıculate	Mınute
V kl andalensıs	406504	0 048	0 046	0 005	Cırcular	Mıcro retıculate	Mınute
V n ngo var *sylvestr s*	253907	0 043	0 042	0 004	Cırcular	Mıcro retıculate	Mınute
V pılosa	541389	0 060	0 061	0 014	Cırcular	Mıcro retıculate	Psılate
V rad ata var *ad ata*	251422	0 042	0 042	0 005	Trıangular	Mıcro retıculate	Mınute
V radıata var *setı losa*	251419	0 043	0 042	0 007	Trıangular	Mıcro retıculate	Mınute
V ı ad ata var *s ıblobata*	281165	0 047	0 047	0 005	Cırcular	Mıcro ret culate	M nute
V st p lacea	256259	0 037	0 037	0 004	Cırcular	Mıcro retıculate	Psılate
V tr lobata	541215	0 037	0 041	0 004	Cırcular	Mıcro ret culate	M nute
V trınerv a var *bou ıeae*	349885	0 047	0 044	0 014	Trıangular	Mıcro ret culate	M nute
V t ıne vıa var *t nerv a*	337486	0 050	0 046	0 012	Trıangular	M cro retıculate	M nute
V ı mbellata var *mbellata*	251441	0 043	0 046	0 004	Cırcular	Mıcro retıcula e	M nute
V ı mbellata var *g acılıs*	251370	0 043	0 046	0 005	Cırcular	M cro retıculate	Mınute
V ng cı lata	298665	0 087	0 085	0 014	Trıangular	M cro ret culate	Ech nate
V ex llata	349723	0 088	0 088	0 015	Trıangular	Scabrate	Ech nate
Mean		0 049	0 049	0 007			
SD		0 015	0 015	0 004			
SE		0 004	0 003	0 001			
CV (%)		30 61	30 61	57 14			

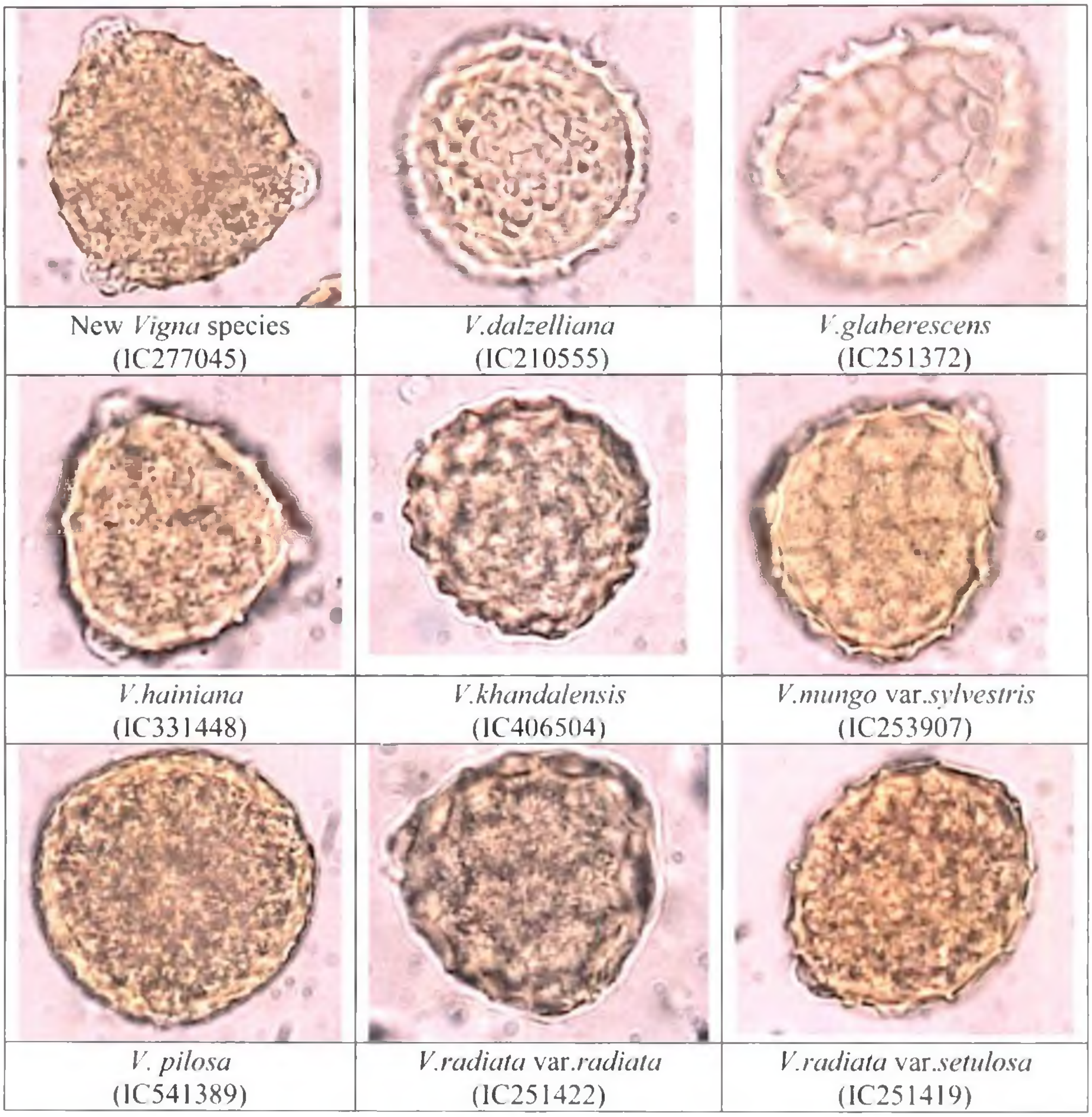
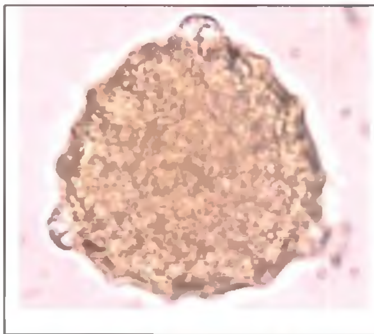
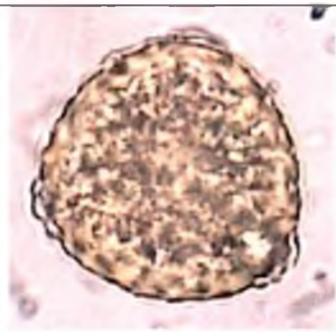


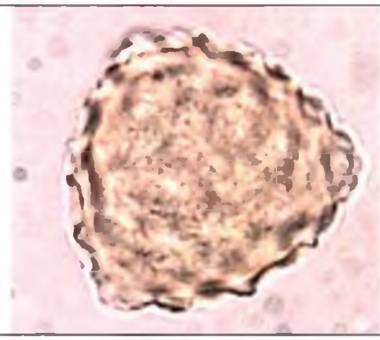
Plate 6a. Pollen morphology of different taxa of *Vigna*



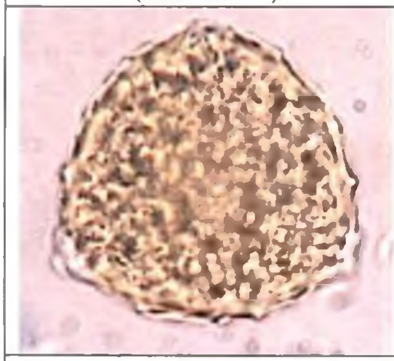
V.radiata var.*sublobata* (IC281165)



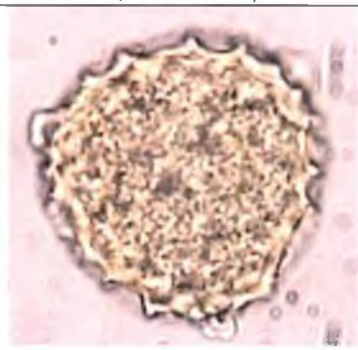
V.stipulacea (IC256259)



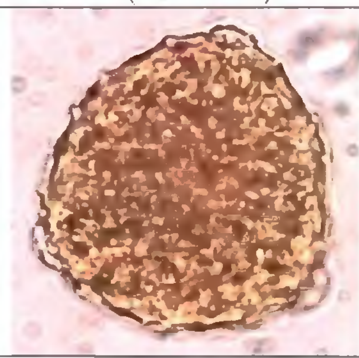
V.trilobata (IC541215)



V.trinervia var.*bourneae* (IC349885)

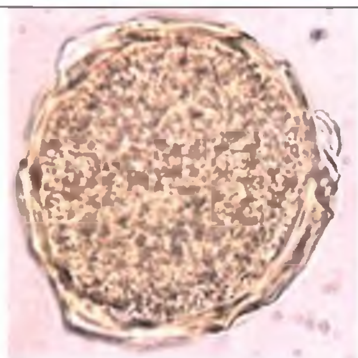


V.trinervia var.*trinervia* (IC337486)

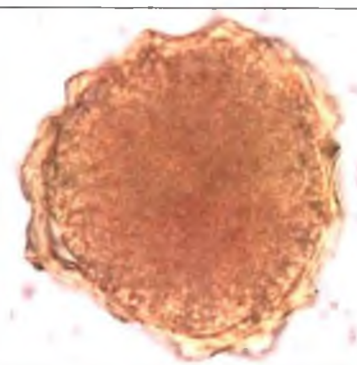


V.umbellata var.*umbellata* (IC251441)

V.umbellata var.*gracilis* (IC251370)



V.unguiculata (IC298665)



V.vexillata (IC349723)

Plate 6b. Pollen morphology of different taxa of *Vigna*

Vigna taxa were monods trizonoporate obtuse and convex The exine thickness of pollen exhibited maximum variability (57 14%) followed by width (30 61%) and length (30 61%) of pollen The length of pollen grains ranged from 0 036 millimicrons to 0 088 millimicrons and width from 0 037 to 0 088 millimicrons The thickness of the exine ranged from 0 004 to 0 015 mill m crons The biggest pollen grains were observed in *V vexillata* followed by *V i ngi iculata* and the smallest in *V haimana* The exine was thin (0 004mµ) in *V haimana* *V trolobata* *V mi ngo* var *sylvestris* *V umbellata* var *i mbellata* and *V stip ilacea* and thick in *V vexillata* (0 015mµ) *V unguici lata* (0 014mµ) and *V p losa* (0 014mµ) The shape of pollen was e ther circular or triangular *V radiata* var *rad ata* *V radiata* var *seti losa* *V t inervia* var *bo u neae* *V triner a* var *tr nervia* *V unguiculata* and *V vexillata* were having triangular pollen grains The sculpturing was micro reticulate in all taxa except *V glabrescens* and *V vexillata* In *V glabresce s* the sculpturing was reticulate and in *V vex llata* it was scabrate The spines on exine were minute in all taxa but ech nate in *V vex llata* and *V i gi ci lata* and ps late n *V pilosa* and *V stipi lacea*

4 2 Biochemical characterisation

Distinct variants from each taxa were selected for b ochemical study The selected access ons and their d stinct morphological features are detailed in Table 16 Out of the 33 accessions selected only 28 could be taken for sozyme study Five access ons Vms7 Vd5 Vd7 Vk and Vp belonging to 3 taxa namely *V s ibran ai ana* *V aconitifol a* and *V mari a* could not be ncluded n the study as the leaf samples obtained were insuffic ent due to delayed and staggered germinat on when compared with other access ons Twenty e ght access ons were subjected o isozyme analys s v tl perox dase (POX) a id poly phenol ox dase (POP) e zy ne The sta ned gel represen ng the pro e n ba ds vh cl ve e sed for

Table 16 Accessıons selected for bıochemıcal characterısatıon

Sl No	Taxa	No of access ons selected	Access ons	D st nct morpholog cal feature
1	New *V gna* specıes	1	V	No varıat on
2	*V dalzell ana*	5	Vd3	Leaf w th wh te patch on upper s de prımary leaf pet ole purple
			Vd5	Leaf w thout wh te patch on upper s de prımary leaf pet ole purple
			Vd7	Leaf w thout wh te patch on upper sıde prımary leaf pet ole green sh purple
			Vd20	Leaf w h green patch on upper s de flowers pale yellow
			Vd21	Leaf w hout any patch flowers golden yellow
3	*V glaberescens*	1	Vg	No varıat on
4	*V ha n ana*	1	Vh9	No varıat on
5	*V khandalens s*	1	Vk	No varıatıon
6	*V m ngo* var *n go*	2	Vmu1	Seed mo tled b ack
			Vmu2	Seed black sh brown
7	*V m ngo* var *sylvestrıs*	2	Vms6	H lum ength short (1 60mm)
			Vms7	H lum length med um (2 32mm)
8	*V p losa*	1	Vp	No va at on
9	*V rad ata* var *rad ata*	1	Vr4	No varıat on
10	*V ad ata* var *s bloba a*	2	V s8	Leaf lobed
			V s10	Leaf unlobed
11	*V rad ata* var *se losa*	1	Vse1	No va a on
12	*V st p lacea*	1	Vs 2	No varıa on
13	*V tr loba a*	3	Vt2	Prımary leaf pet ole g een sh purple c mb ng hab t
			Vt11	Prımary eaf pet ole green cl mb ng hab t
			V 12	Prımary eaf pet ole green sh purple erect hab
14	*V tr ervıa* var *bo eae*	3	Vtb7	Prımary leaf pet ole g een sh purple pe ole green leaves unlobed
			Vtb8	Prımary leaf pe ole purple pet o e g een sh purple leaves shallowly lobed
			V b10	Prımary leaf pe ole and leaf pe o e green sh purp e leaves shal owly lobed
15	*V t erv a* var *tr e v a*	1	Vtt	No va a on
16	*V l n bella a*	2	Vu3	Seeds l gh g een sh b own
			Vu7	Seeds g een sh yellow
17	*V n bella a* var *grac l s*	2	Vug1	F owers golden yellow seeds mottled black
			Vug3	F owe s pale yellow seeds black
18	*V g c la a*	2	Vun1	Seed co o b own
			Vun2	Seed colo c eam
19	*V ve lla a*	1	V 4	No va at on
	To al	3		

data scoring is presented in Plate 7 for POX and in Plate 8 for POP Twelve putative loci were scored five for POX and seven for PPO Agglomerative hierarchical clustering was performed on the Jaccard s similarity co efficient matrix utilizing the UPGMA method using 12 protein bands over the 28 accessions and the resulting dendrogram is presented in Figure 4 From the figure 4 it can be seen that the 28 accessions could be grouped into 4 clusters at 75 percent similarity The accessions included in each cluster are represented in Table 17

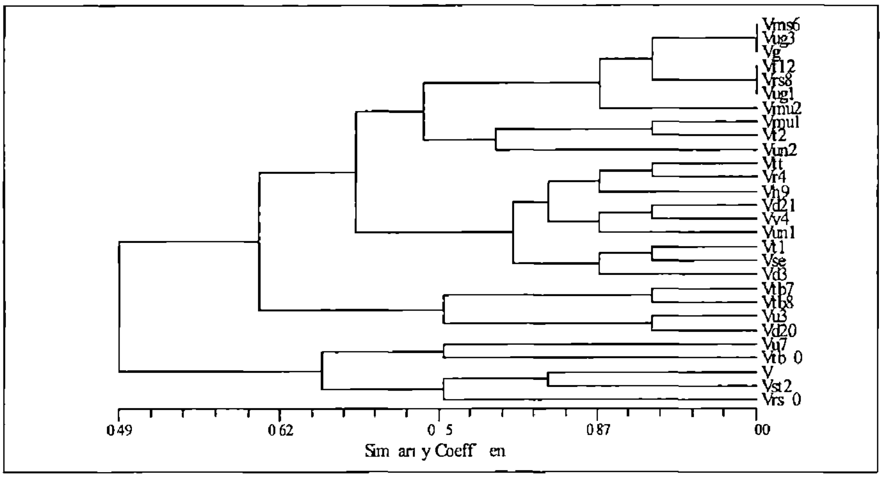


Fig 4 Dendrogram based on isozyme markers

4 3 Molecular characterisation

4 3 1 ISSR analysis

All the 33 selected access ons l sted n Table 15 were subjected to ISSR analys s using 10 ISSR primers All the 10 primers used i the study produced unamb guous markers The ten ISSR prime s produced a total of 153 marke s across 33 genotypes and all were

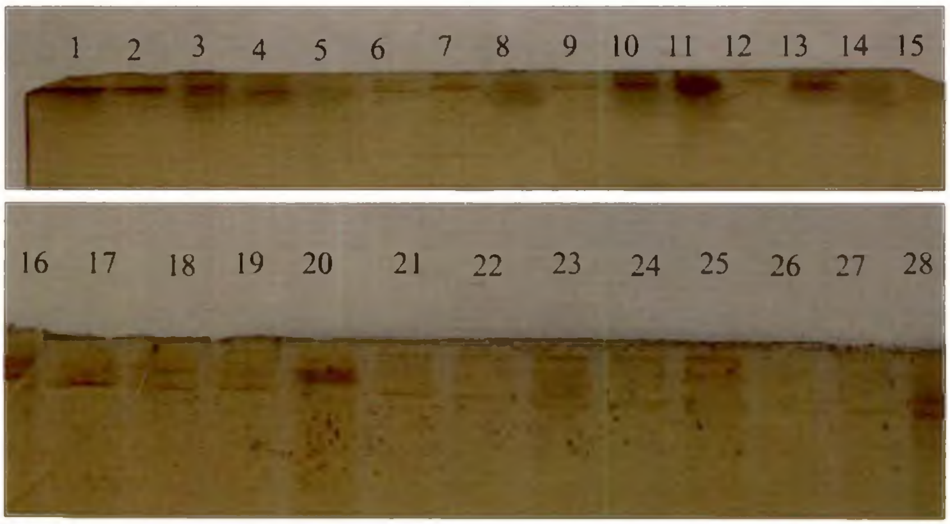


Plate 7. Isozyme marker profile of different taxa of *Vigna* based on peroxidase enzyme

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vms6	Vt12	Vtb7	Vmu2	Vtt	Vug3	Vt11	Vu3	V	Vtb8	Vrs8	Vu7	Vug1	Vg	Vd20

16	17	18	19	20	21	22	23	24	25	26	27	28
Vtb10	Vmu1	Vr4	Vun2	Vt2	Vh9	Vst2	Vd21	Vse1	Vd3	Vrs10	Vun1	Vv4

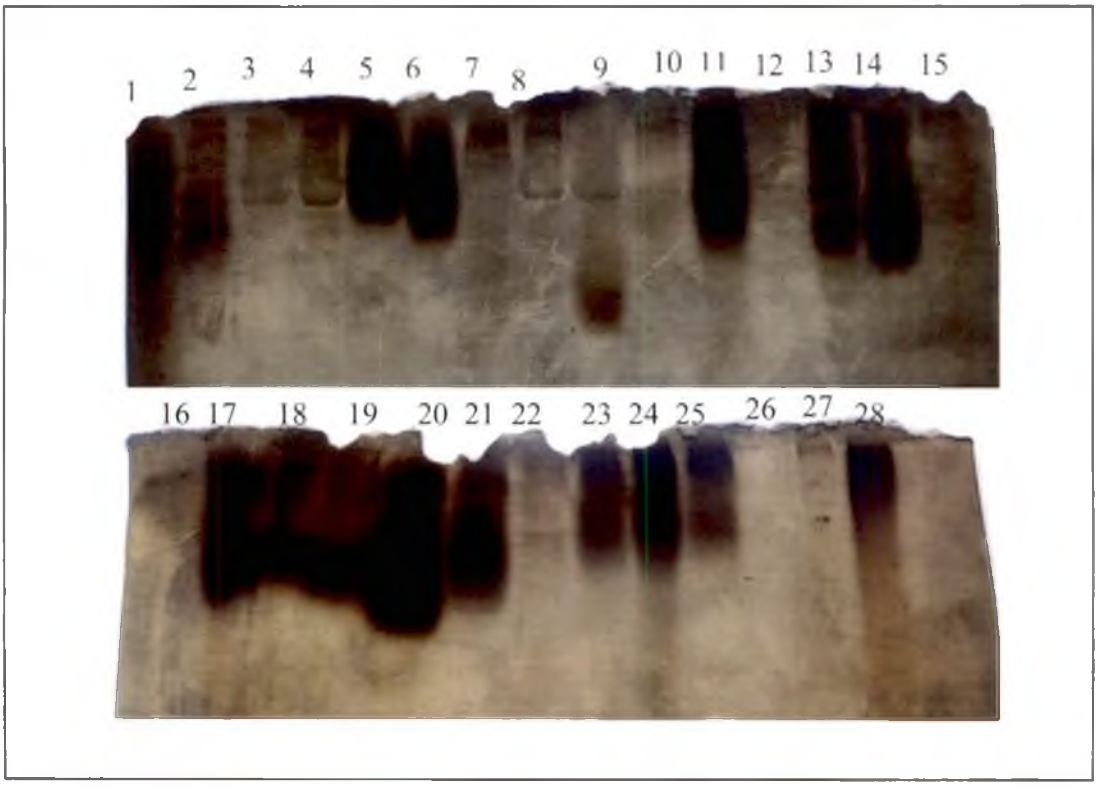


Plate 8. Isozyme marker profile of different taxa of *Vigna* based on poly phenol oxidase enzyme

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vms6	Vt12	Vtb7	Vmu2	Vtt	Vug3	Vt11	Vu3	V	Vtb8	Vrs8	Vu7	Vug1	Vg	Vd20

16	17	18	19	20	21	22	23	24	25	26	27	28
Vtb10	Vmu1	Vr4	Vun2	Vt2	Vh9	Vst2	Vd21	Vse1	Vd3	Vrs10	Vun1	Vv4

Table 17 Clusterıng pattern based on ısozyme markers

Sl No	Cluster No	No of accessıons	Code of accessıons	Taxa
1	I	10	Vms6	*V mı ngo* var *sylvesrıs*
			Vug1 Vug3	*V ı mbellata* var *gracılıs*
			Vg	*V glabrescens*
			Vt2 Vt12	*V trılobata*
			Vrs8	*V radıata* var *s ıblobata*
			Vmu1 Vmu2	*V mı ngo* var *mıngo*
			Vun2	*V ıngı cıdata*
2	II	9	Vtt	*V tı ınervıa* var *tı ıervıa*
			Vr4	*V adıata* var *radıata*
			Vh9	*V ha nıana*
			Vd3 Vd21	*V dalzell ana*
			Vv4	*V vex llata*
			Vun1	*V ı ng ıcı lata*
			Vt11	*V t lobata*
			Vse1	*V ra l ata* var *set losa*
3	III	4	Vtb7 Vtb8	*V t ne ·vıa* var *boı eae*
			Vu3	*V ı mbellata* var *ı n bellata*
			Vd20	*V dalzellıa a*
4	IV	5	Vu7	*V n bellata*
			Vtb10	*V t ı ι ·v a* var *bo neae*
			V	New *Vıg a* specıes
			Vst2	*V st p lacea*
			Vrs10	*V ad ta* var *sı blobata*

polymorphic The numbers of polymorphic bands obtained with each of the primer are furnished in Table 18 Among the primers used the primer UBC 842 produced the highest number of fragments (23) while the primers UBC 813 and UBC 856 produced the lowest number of fragments (10) The ISSR marker profile for the 33 *Vigna* genotypes generated by the primers UBC 841 UBC 842 UBC 857 UBC 809 UBC 840 and UBC 810 are shown in Plates 9a b c d e and f respectively No band was observed for genotypes Vse1 Vrs8 and Vrs10 with any of the primers

Table 18 Polymorphic bands produced in 33 taxa of *Vigna* w th 10 ISSR primers

Sl No	Primer code	Number of markers	Number of polymorphic markers
1	UBC 809	13	13
2	UBC 810	15	15
3	UBC 812	21	21
4	UBC 813	10	10
5	UBC 816	13	13
6	UBC 840	16	16
7	UBC 841	14	14
8	UBC 842	23	23
9	UBC 856	10	10
10	UBC 857	18	18
	Total	153	153

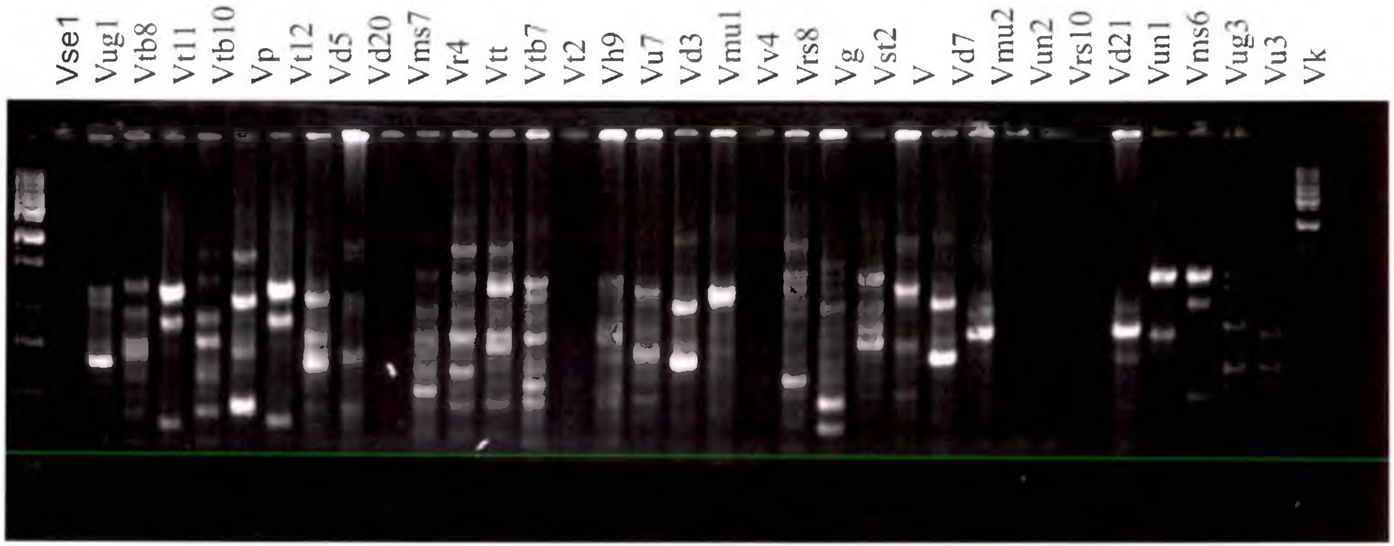


Plate 9a. ISSR marker profile using primer UBC841

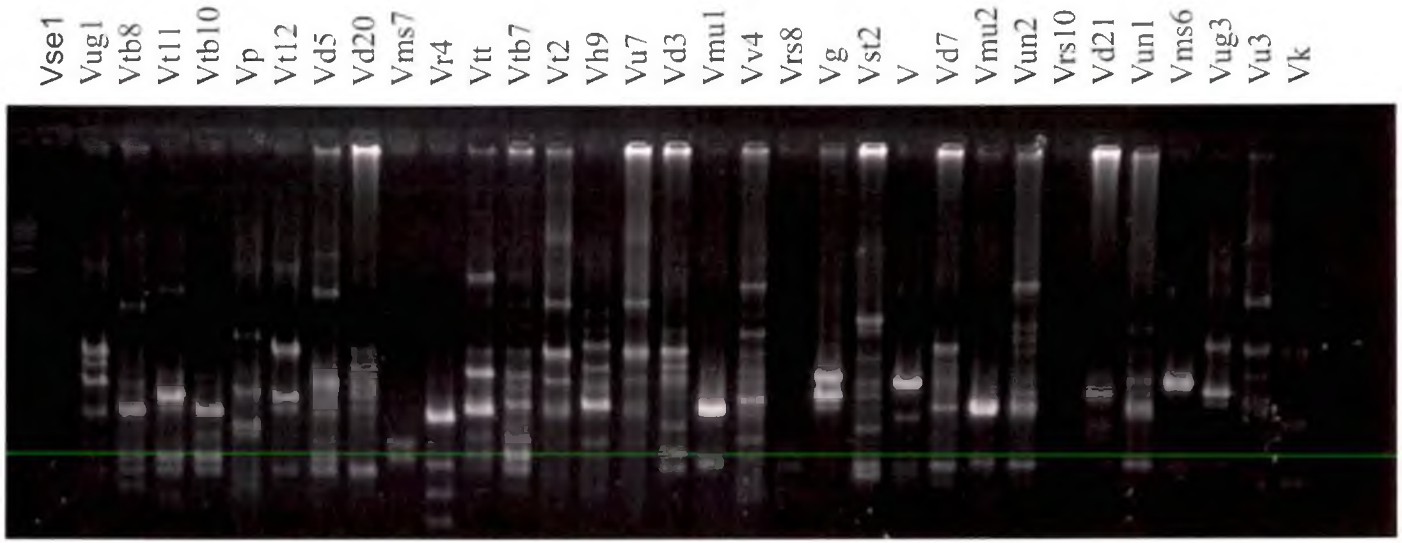


Plate 9b. ISSR marker profile using primer UBC842

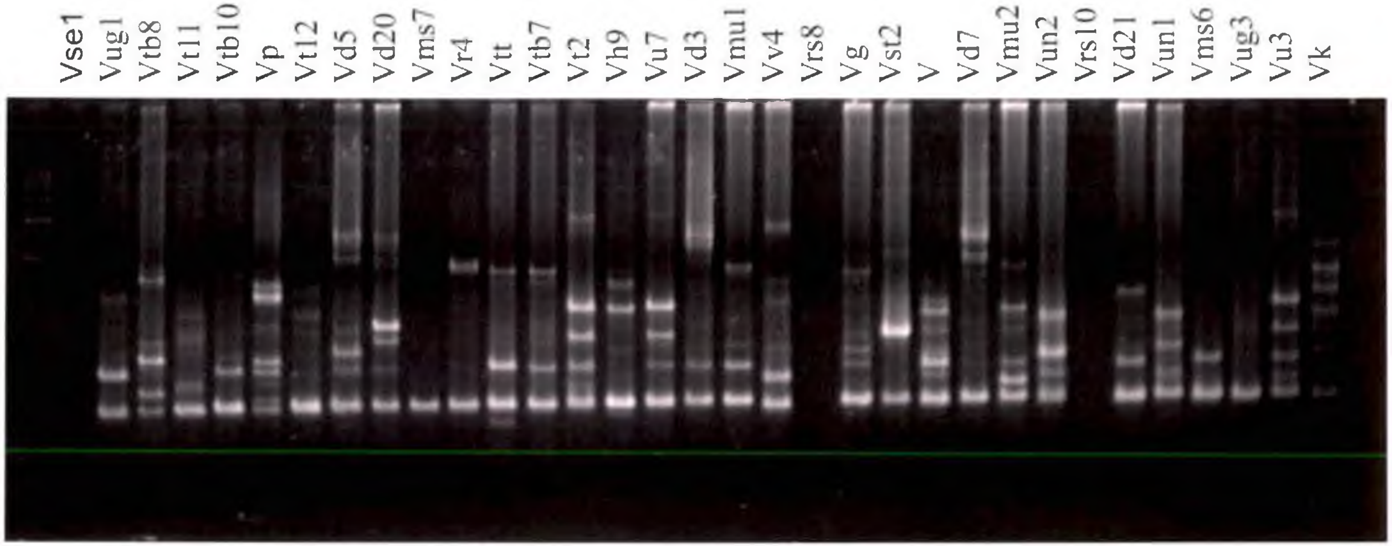


Plate 9c. ISSR marker profile using primer UBC857

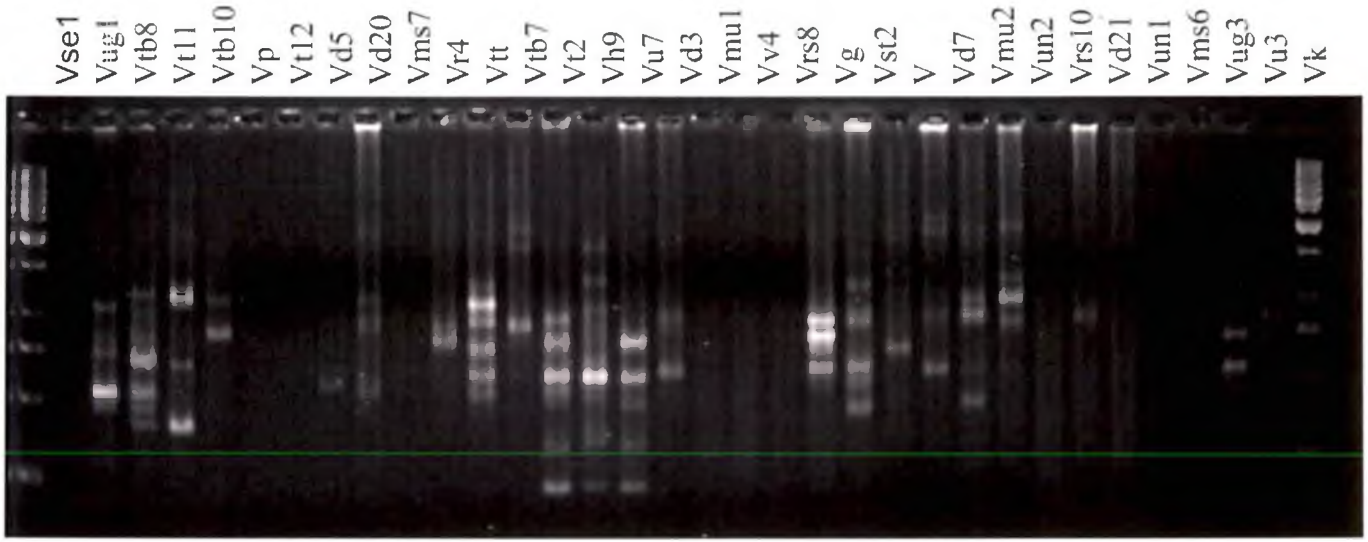


Plate 9d. ISSR marker profile using primer UBC809

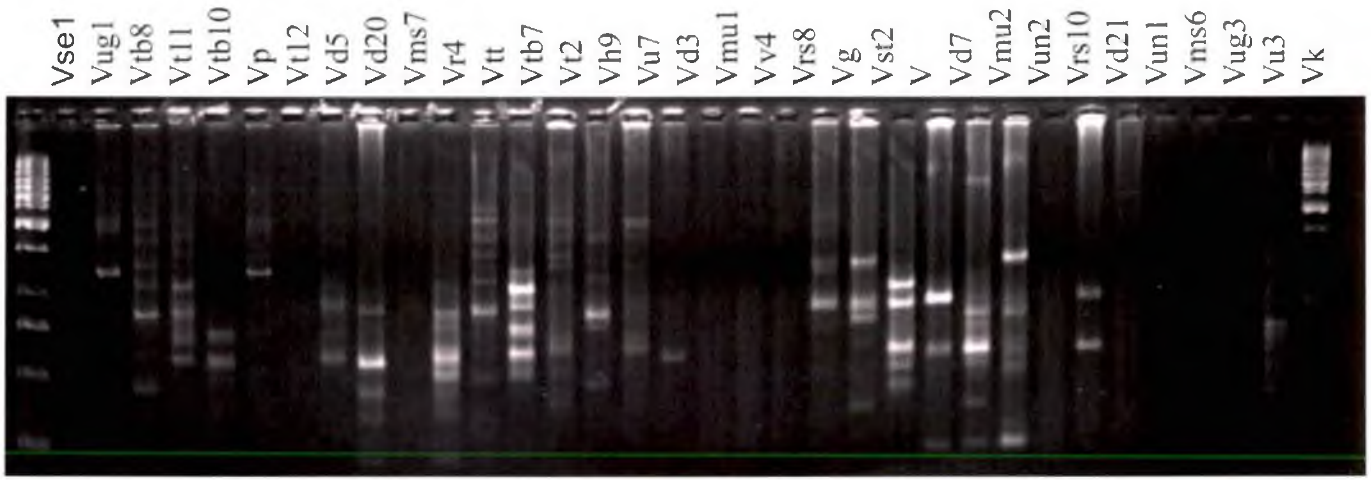


Plate 9e. ISSR marker profile using primer UBC840

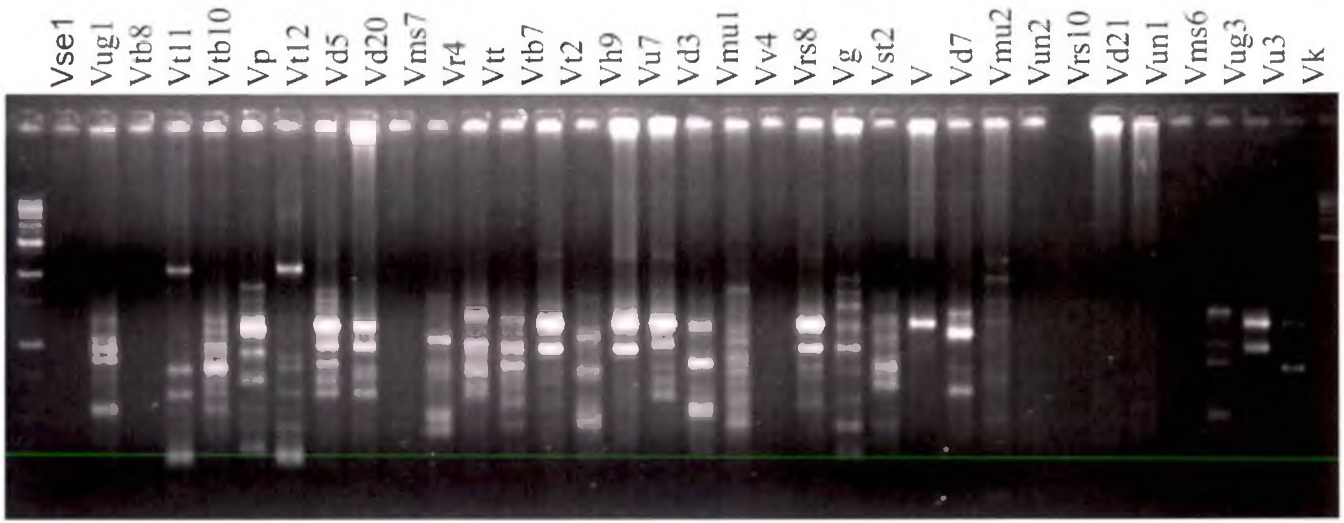


Plate 9f. ISSR marker profile using primer UBC810

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4 3 2 Cluster analysis

Agglomerative hierarchical clustering was performed by UPGMA method using Jaccard s similarity co efficient matrix with the 153 polymorphic bands over 33 accessions evaluated The resulting dendrogram is presented in Figure 5 These 33 accessions formed 12 clusters at 70 percent similarity level The 12 clusters along with the taxa included in each cluster are presented in Table 19

4 4 Comparison of different clustering patterns

The analysis based on qualitative characters resulted in ten clusters and that based on quantitative characters resulted in five clusters To find out the homology between these clustering patterns the taxa wise distribution of accessions of each qualitative cluster were worked out and presented in Table 20 From this table it can be seen that 86 67 percent of accessions of the taxa *V radiata* var *sublobata* of qualitative cluster I were falling in quantitative cluster I In the case of *V radiata* var *setulosa* *V subramaniana* and *V radiata* var *radiata* belonging to qualitative cluster I 83 33 100 00 and 85 71 percent of accessions respectively were found to fall into a single quantitative cluster (cluster III) Similarly in qualitative cluster II 100 00 and 94 74 percent of accessions of *V trinervia* var *trinervia* and *V trinervia* var *bourneae* respectively fell in quantitative cluster V Under qualitative cluster III 100 00 percent of accessions of two taxa *viz* *V hainiana* and the new *Vigna* species fell in quantitative cluster II and 95 45 percent of accessions belonging to the taxa *V mungo* var *sylvestris* fell in quantitative cluster III The only two accessions of taxa *V mungo* var *mungo* fell in two different quantitative clusters viz III and IV In qualitative cluster V 100 00 and 92 31 percent of accessions belonging to *V stipulaceae* and *V trilobata* fell in quantitative

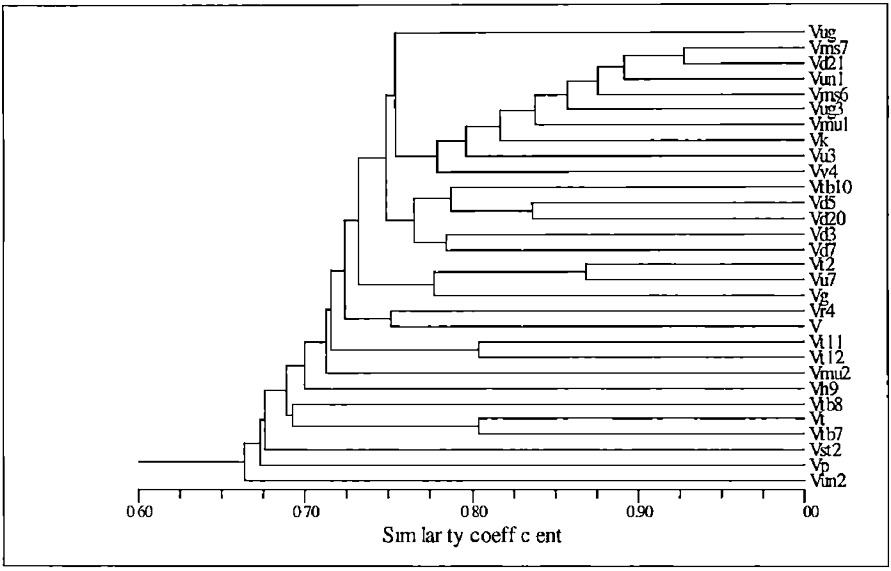


Fig 5 Dendrogram based on ISSR markers

Table 19 Clustering pattern based on molecular markers

Sl No	Cluster No	No of accessions	Code of accessions	Taxa
1	I	15	Vrs8 Vrs10	*V radıata* var *sublobata*
			Vse1	*V radıata* var.*setulosa*
			Vr4	*V radıata* var *radıata*
			Vms6 Vms7	*V mungo* var *sylvesrıs*
			Vd3 Vd7 Vd21	*V dalzellıana*
			Vun1	*V unguıculata*
			Vug3	*V umbellata* var *gracılıs*
			Vmu1	*V n ungo* var *ı ngo*
			Vk	*V khandalensıs*
			Vu3	*V ı mbellata* var *ı mbellata*
			Vv4	*V vexıllata*
2	II	3	Vtb10	*V trı erv a* var *boı rneae*
			Vd5 Vd20	*V dalzellıana*
3	III	3	Vt2	*V trılobata*
			Vu7	*V ı mbellata* var *ı n bellata*
			Vg	*V glabrescen s*
4	IV	1	Vug1	*V n bellata* var *grac lıs*
5	V	2	Vt11 Vt12	*V trılobata*
6	VI	2	V	New *Vıgna* specıes
			Vmu2	*V n ı go* var *n go*
7	VII	1	Vh9	*V haınıana*
8	VIII	1	Vtb8	*V t ı e v a* var *boı rneae*
9	IX	2	Vtt	*V t e v a* var *t ne v a*
			Vtb7	*V trı ervıa* var *boı r eae*
10	X	1	Vp	*V pılosa*
11	XI	1	Vst2	*V stıp lacea*
12	XII	1	Vun2	*V gı cı lata*

Table 20 Homology between clustering pattern based on qualitat ve and quantitative characters

Qualitative cluster	No of accessions	Taxa	No of accessions taxa wise	Quantitative clusters				
				I	II	III	IV	V
I	31	*V radiata* var *sublobata*	15	86 67		13 33		
		V radiata var *setulosa*	6	16 67		83 33		
		V subramaniana	3			100 00		
		V radiata var *radiata*	7	14 29		85 71		
Cluster members				48 39		51 61		
II	20	*V trinervia* var *bourneae*	19	5 26				94 74
		V tr nervia var *trinervia*	1					100 00
Cluster members				5 00				95 00
III	36	*V hainiana*	10		100 00			
		V mungo var *sylvestris*	22	4 55		95 45		
		V mungo var *mungo*	2			50 00	50 00	
		New *Vigna* species	1		100 00			
		V dalzelliana	1	100 00				
Cluster members				5 56	30 56	61 11	2 78	
IV	1	*V khandalens s*	1				100 00	
V	16	*V stipulacea*	3		100 00			
		V tr lobata	13	92 31	7 69			
Cluster members				75 00	25 00			
VI	1	*V glab escens*	1				100 00	
VII	35	*V dalzelliana*	20	85 00	5 00		10 00	
		V umbellata var *i mbellata*	11			100 00		
		V umbellata var *gracilis*	4	100 00				
Cluster members				60 00	2 86		37 14	
VIII	1	*V acon tifol a*	1		100 00			
IX	7	*V vex llata*	4					100 00
		V u g ci lata	3				100 00	
Cluster members							42 86	57 14
X	2	*V ma i ia*	1		100 00			
		V pilosa	1				100 00	
Cluster members					50 00		50 00	

cluster II and I respectively When the qualitative cluster VII is considered 100 00 percent of accessions belonging to taxa *V ι mbellata* var *umbellata* and *V umbellata* var *gracilis* of this cluster fell into quantitative cluster III and I respectively Nearly 85 00 percent of accessions of the taxa *V dalzelliana* aga n belong ng to the same qualitative cluster fell in quantitative cluster I Qualitative cluster IX comprised of two taxa namely *V vexillata* and *V unguiculata* and 100 00 percent accessions of both these taxa fell in quantitative cluster V and IV respectively Similarly n the case of qual tative cluster X 100 00 percent of accessions belong ng to taxa *V marina* and *V pilosa* fell in quantitat ve cluster II and IV respectively

The clusters IV VI and VIII formed based on qualitative characters comprised of only one taxa each *V khandalensis* *V glabrescens* and *V aconitifol a* respect vely Each of these taxa was represented by single accession only *V khanadalensis* and *V glabrescens* fell n quantitat ve cluster IV and *V aconit folia* fell in quantitative cluster II The taxa belonging to each qualitative cluster and proport on of accessions n each taxa falling in different quantitat ve clusters are presented d agrammat cally in Figure 6

The mean standard dev at on (SD) and coeff c ent of variation (CV) computed for all the 24 quantitative characters of each of the quant tative clusters is presented in Table 21 When the variability among the cluster members for each of the quantitat ve clusters were revie ved t vas observed that number of lobes of terminal leaflet yield per plant peduncle length days to flowering and flower bud size were the most variable characters in cluster I Number of lobes of term nal leaflet y eld per plant flower bud size and 100 seed we ght of cluster members contributed for max num var ab l ty in clus er II In cluster III number of lobes of term nal leaflet y eld per plan number of seeds per pod days to flowering and 100 seed ve ght we e tl e mos a able charac e W l egard to cluster IV the most variable

Table 21 Summary statistics of quantitative characters in different quantitative clusters

Character	Cluster I			Cluster II			Cluster III			Cluster IV			Cluster V		
	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
Primary leaf length (cm)	1.58	0.40	25.50	2.09	0.66	31.61	3.48	0.82	23.67	4.95	1.29	26.04	2.12	0.68	32.17
Primary leaf width (cm)	1.16	0.18	15.76	1.11	0.23	20.60	1.40	0.26	18.78	1.88	0.83	44.45	1.44	0.23	16.17
Terminal petiolule length (cm)	1.61	0.35	21.62	1.66	0.43	25.57	2.01	0.42	20.87	2.77	0.58	20.95	2.00	0.51	25.71
Terminal leaflet length (cm)	6.03	1.37	22.65	7.04	2.38	33.86	8.83	1.23	13.92	12.30	1.55	12.57	8.71	1.31	14.99
Terminal leaflet width (cm)	4.99	1.03	20.69	5.19	1.62	31.15	6.89	1.32	19.18	8.52	1.86	21.80	6.96	1.72	24.79
Petiole length (cm)	7.93	2.71	34.22	6.33	2.23	35.19	9.25	2.36	25.47	16.41	5.07	30.90	9.59	2.87	29.88
Days to flowering	76.61	32.04	41.83	61.83	20.12	32.55	52.82	17.91	33.91	80.33	33.77	42.04	106.12	30.33	28.58
Flower bud size (cm ^{2})	1.22	0.49	40.11	0.76	0.69	90.68	1.75	0.40	22.80	3.31	1.35	40.81	3.66	3.29	89.68
Bracteole size (mm)	1.63	0.60	36.79	1.28	0.57	44.96	2.79	0.41	14.81	1.00	0.84	84.02	2.52	0.87	34.59
No of flowers/raceme	5.41	1.34	24.84	4.11	1.78	43.26	6.87	1.65	23.98	7.94	3.02	38.00	4.28	0.68	15.85
Length of keel pocket (mm)	2.86	0.57	19.78	1.33	0.69	51.45	3.53	0.56	15.79	2.78	1.70	61.19	2.84	0.37	13.17
Peduncle length (cm)	13.72	6.03	43.98	9.20	4.17	45.32	11.67	2.89	24.72	14.77	6.42	43.45	17.85	5.20	29.14
No of pods/peduncle	3.10	0.68	21.86	2.83	0.51	18.16	3.22	0.71	22.15	4.47	1.37	30.75	2.33	0.52	22.13
Pod length (cm)	4.57	0.57	12.54	3.91	0.82	20.97	4.63	1.22	26.24	8.65	2.32	26.79	6.41	1.75	27.37
No of seeds/pod	10.45	1.55	14.81	7.73	2.55	33.06	11.49	10.67	92.91	8.23	1.98	24.10	11.86	3.03	25.54
100 seed weight (g)	0.93	0.19	20.60	0.93	0.84	90.91	1.64	0.51	31.35	5.70	1.78	31.27	1.43	0.34	23.92
Seed length (mm)	2.77	0.30	10.65	2.64	0.78	29.72	3.14	0.39	12.44	6.43	1.12	17.39	3.31	0.53	16.03
Seed width (mm)	2.12	0.23	11.06	2.02	0.65	32.48	2.66	0.28	10.35	3.86	0.61	15.84	2.64	0.38	14.24
Hilum length (mm)	1.71	0.24	14.30	1.21	0.47	38.79	1.92	0.52	27.11	3.09	0.59	19.24	1.81	0.37	20.37
Yield/plant (g)	29.80	17.77	59.64	13.04	14.56	111.60	121.79	237.76	195.22	81.52	61.76	75.76	38.61	44.05	114.09
Days to emergence	9.47	1.70	17.96	9.00	3.73	41.40	6.32	1.96	31.04	4.00	2.11	52.86	8.60	3.16	36.77
No of primary branches	3.61	0.75	20.80	3.33	0.59	17.82	2.84	0.79	27.77	2.39	1.04	43.41	3.00	0.00	0.00
No of lobes of terminal leaflet	2.18	1.35	62.12	0.94	1.63	172.16	0.32	0.93	295.46	1.83	1.50	82.09	2.28	1.31	57.35
Days to first pod maturity	91.18	28.93	31.73	78.94	23.95	30.34	76.08	17.81	23.41	96.39	33.45	34.70	94.84	28.94	30.52

characters were bracteole size number of lobes of terminal leaflet yield per plant length of keel pocket and days to emergence In cluster V the characters contributing to maximum variability were yield per plant flower bud size number of lobes of terminal leaf let and days to emergence

The range for various quantitative characters in each taxa of *Vigna* is presented in Table 22 The weighted averages of various quantitative characters computed for each taxa are presented in Table 23 Key characters for each taxa were dentified as those characters which had a coefficient of variat on of above 25 percent in the respective quantitative clusters n which the accessions of the taxa were d stributed These key quantitative characters served as a statistical key for distingu shing various taxa and are represented diagrammatically in figures 7a to 7h

The key quantitative characters thus ident fied for taxa *V radiata va s blobata* belonging to qualitat ve cluster I and d stributed in quantitative cluster I and III were days to flowering yield/plant peduncle length number of lobes of terminal leaflet flower bud size and bracteole s ze S m larly key qua t tative characters for taxa *V adiata* var *setulosa* and *V radiata* var *radiata* belong ng to qualitative cluster I and distributed in quant tat ve clusters III and I were number of lobes of term nal leaflet yield/plant number of seeds/pod days to flower ng 100 seed we ght and days to emergence The key quant tative characters for taxa *V s b an an a a* of qual tative cluster I and belonging to quantitative cluster III were also number of lobes of terminal leaflet yield/plant number of seeds pod days to flowering 100 seed we ght and days to emergence

The key quant tative characters dentified for taxa *V t e v a a e a* and V *e* var *bo e e* of qual tat e clus e II d stnb ed n quant a ve clus er V and V

Table 22 Range for various quantitative characters in different taxa

Characters	*V dalzelliana*	*V l a n ana*	*V mungo* var *mungo*	*V mungo* var *sylvestris*	*V radiata* var *radiata*	*V radiata* var *sublobata*	*V radiata* var *setulosa*	*V stipulaceae*
Days to emergence	8 00 13 00	6 00 20 00	3 00	3 00 14 00	3 00 11 00	6 00 11 00	6 00 8 00	8 00 9 00
Primary leaflet length (cm)	1 15 1 97	1 40 2 90	4 43 5 30	2 05 3 77	2 5 5 60	1 00 2 83	2 03 4 57	0 90 1 45
Primary leaflet width (cm)	0 95 1 67	0 70 1 30	0 93 1 67	0 80 1 70	1 20 1 97	0 60 1 60	0 93 1 33	0 73 1 10
Terminal petiolule length (cm)	1 10 2 97	1 50 2 70	2 73 2 80	1 07 2 30	1 83 3 07	1 53 2 27	1 80 2 63	0 80 1 47
No of lobes of terminal leaflet	0 00 3 00	0 00	0 00	0 00	0 00 3 00	0 00 3 00	0 00	3 00
Terminal leaflet length (cm)	1 37 11 13	6 00 12 00	9 97 10 83	6 87 10 63	6 97 12 30	5 46 10 17	6 37 10 17	2 10 4 40
Terminal leaflet width (cm)	3 6 10 00	2 60 7 33	8 17 8 20	4 17 7 13	5 33 9 20	5 27 9 57	5 60 9 70	1 93 4 10
Petiole length (cm)	5 07 15 67	4 50 14 00	12 00 15 00	6 50 12 00	7 90 12 43	5 97 16 67	6 20 10 00	3 73 5 53
No of primary branches	3 00 5 00	3 00 4 00	2 00	2 00 3 00	2 00 4 00	3 0 4 0	3 00 4 00	3 00 5 00
Days to flowering	53 00 148 00	45 00 75 00	86 00 127 00	42 00 126 00	33 00 63 00	39 00 67 00	37 00 62 00	48 00 85 00
Flower bud size (cm^2)	0 42 1 92	0 40 0 64	1 65	1 10 2 24	1 10 2 72	0 45 2 40	1 20 2 55	0 63 0 70
Bracteole size (mm)	1 00	1 00	3 00	3 00	2 00	2 00	3 00	2 00
No of flowers raceme	3 00 6 00	3 00 8 00	5 00	6 00	5 00 10 00	4 00 9 00	6 00 9 00	3 00 5 00
Length of keel pocket (mm)	3 00	1 00	2 00	4 00	3 00	3 00	3 00	2 00
Peduncle length (cm)	7 33 16 40	5 20 18 50	14 00 15 00	6 97 19 67	11 90 18 50	5 67 17 33	8 50 15 40	5 67 7 83
No of pods peduncle	2 00 3 00	2 00 3 00	0 00	3 00	3 00 7 00	3 00 4 00	3 00 4 00	3 00
Days to first pod maturity	68 00 171 00	63 00 92 00	44 00 95 00	75 00 99 00	48 00 83 00	56 00 89 00	50 00 96 00	66 00 76 00
Pod length (cm)	3 34 5 22	3 12 5 36	3 90 4 24	2 90 4 04	4 86 6 68	4 00 5 36	3 70 7 14	2 46 3 82
No of seeds pod	7 00 11 40	8 20 11 40	5 60 6 20	5 80 9 60	9 20 12 60	9 20 13 4	10 00 14 8	6 20 8 00
100 seed weight (g)	0 68 1 29	0 49 0 85	2 83 4 56	0 80 2 85	1 71 3 13	0 67 1 32	0 82 1 71	0 45 1 03
Seed length (mm)	2 39 3 26	2 03 2 60	3 97 4 94	2 87 3 92	2 94 3 90	2 42 3 01	2 37 3 53	2 10 2 75
Seed width (mm)	1 70 2 83	1 52 2 08	2 83 3 67	2 32 3 22	2 18 3 24	1 95 2 67	2 11 2 87	1 81 1 92
Hilum length (mm)	1 07 2 16	0 83 1 23	2 41 3 41	1 60 2 82	1 48 2 50	1 13 2 39	1 23 1 67	1 06 1 18
Yield plant (g)	2 00 87 52	0 52 23 48	60 70 126 29	25 30 1090 00	4 50 471 00	15 99 70 63	16 72 63 09	1 50 16 00

Table 22 cont nued

Cl ı acters	*V subraman ana*	*V tr lobata*	*V tr nerv a* var *bour ıeae*	*V umbellata var ı mbellata*	*V umbellata* var *gracılıs*	*V unguıculata*	*V vexıllata*
Days to ɩmɛ ɡe ce	6 00	8 00 11 00	3 00 19 00	3 00 8 00	8 00 11 00	2 30 3 00	8 00 11 00
P mary lcaf le ıgth (cm)	? 60 4 10	0 93 1 ͻ3	1 40 2 53	3 20 6 40	1 17 1 83	3 80 6 73	2 70 3 83
Prımary leaf w dth (cm)	1 33 2 00	0 83 1 23	1 00 1 90	0 80 1 70	0 97 1 30	2 47 3 90	1 07 1 53
Term nal petıolule length (cm)	1 83 2 07	1 13 1 87	1 10 2 90	2 07 3 73	1 13 1 30	2 77 3 17	1 10 1 87
No of lobes of term nal leaflet	0 00	3 00	0 00 3 00	3 00	0 00	0 00	0 00
Term nal leaflet length (cm)	7 57 8 37	3 30 5 10	6 97 10 67	10 67 13 67	5 90 7 17	10 97 13 47	6 67 7 43
Term nal leaflet wıdtl (cm)	6 57 8 50	3 03 5 17	5 07 9 47	6 33 9 83	3 63 4 10	7 00 9 33	3 67 5 00
Petıole length (c n)	5 67 6 93	5 33 10 67	5 50 13 83	12 67 23 67	3 5 6 33	12 17 15 33	4 33 7 50
No of pr mary branches	4 00	3 00	3 00	2 00	3 00	3 00	3 00
Days to flowerıng	39 00 45 00	45 00 55 00	57 00 141 00	45 00 87 00	51 00 69 00	48 00 98 00	68 00 75 00
Flo ver bud s ze (cm)	1 76 2 70	0 40 0 90	1 43 3 40	1 95 3 80	1 10 1 80	5 52 5 75	6 60 12 58
Bracteolc sıze (n n)	3 00	? 00	3 00	1 00	1 00	0 00	1 00
No of flowers race ne	9 00	4 00 5 00	4 00	8 00	4 00	4 00	4 00 6 00
Length of keel pocket (mm)	3 00	2 00	3 00	4 00	4 00	0 00	2 00
Peduncle length (cm)	9 00 11 17	15 33 39 33	8 57 30 33	9 00 18 67	9 67 12 00	13 67 15 60	13 33 18 50
No of pods pedu ıcle	3 00	3 00	0 00	5 00	2 00	2 00	2 00
Days to f rst pod maturıty	68 00 71 00	62 00 80 00	61 00 119 0	62 00 102 00	71 00 96 00	61 00 113 00	86 00 103 00
Pod length (cm)	6 08 6 64	4 76 5 34	4 60 6 ͻ0	5 60 11 10	4 88 5 90	11 8 12 46	7 80 11 94
No of seeds pod	10 60 14 40	1 40 12 60	9 80 14 20	5 80 9 60	10 20 11 20	10 6 12 00	12 20 18 6
100 seed we gh (ɡ)	1 35 1 57	0 75 0 88	0 67 2 31	4 57 7 53	0 95 1 27	4 28 11 34	1 06 1 83
Seed length (mm)	2 60 2 87	2 35 2 58	2 58 3 64	5 92 8 32	2 93 3 91	5 48 7 44	4 18 4 84
Seed w dth (mm)	2 20 2 51	1 89 1 92	2 02 3 36	2 84 4 33	1 95 2 43	3 50 5 55	2 52 3 02
H lum length (mm)	0 80 1 00	1 20 1 64	1 28 2 63	2 78 4 04	1 14 1 76	2 25 3 61	2 03 2 18
Y eld plant (ɡ)	14 60 33 99	9 79 33 09	5 51 161 08	43 36 191 41	18 49 22 23	24 24 55 70	1 47 12 67

Table 23 We ghted averages of various quant tat ve characters in d fferent taxa Table 23 c

Tax	Pr mary leaf length (cm)	Pr mary leaf w dth (cm)	Terminal petiolule length (cm)	Terminal leaflet length (cm)	Terminal leaflet width (cm)	Pet ole length (cm)	Days to flowering¶	Flower bud size (cm^2)	Bracteole s ze (mm)	No of flowers/ raceme¶	Length of keel pocket (mm)	Peduncle length (cm)	No of pods/ peduncle
New *V gna* spec es	2 17	1 10	1 50	8 67	2 80	6 60	55 00	1 65	2 00	8 00	2 00	8 00	3 00
V acon fol a	3 30	1 00	1 57	5 70	5 53	6 87	84 00	0 30	2 00	4 00	1 00	3 40	3 00
V l l cll na	1 53	1 27	1 69	7 15	5 44	9 37	111 00	1 13	1 00	5 00	3 00	10 49	3 00
V glabe cscens	2 87	2 20	2 73	14 83	11 47	26 33	83 00	2 50	1 00	8 00	2 00	37 00	7 00
V l a n ana	2 27	1 08	1 84	8 31	5 96	6 79	55 00	0 49	1 00	4 00	1 00	10 65	3 00
V kl dalcn	3 73	1 93	1 70	13 43	12 67	10 10	155 00	1 82	3 00	15 00	2 00	17 40	5 00
I na	2 70	1 60	2 10	7 57	6 20	6 63	127 00	3 24	0 00	1 00	0 00	3 60	1 00
V go va *n go*	4 87	1 30	2 77	10 40	8 19	13 50	107 00	1 65	3 00	5 00	2 00	14 50	3 00
I n go v r *ylvc*	3 16	1 41	1 77	8 50	6 03	8 95	60 00	1 74	3 00	6 00	4 00	10 94	3 00
V p l a	3 15	2 65	1 63	8 47	5 30	6 43	168 00	5 52	0 00	15 00	0 00	6 50	3 00
V l ata a l ta	4 12	1 51	2 43	9 74	7 69	10 01	40 00	1 64	2 00	8 00	3 00	14 34	5 00
V l a a va *l oba a*	1 94	1 14	1 88	6 49	6 11	8 20	58 00	1 65	2 00	8 00	3 00	11 69	4 00
V l ata va *e losa*	3 47	1 14	2 04	8 29	7 60	7 68	50 00	1 67	3 00	9 00	3 00	11 63	4 00
I s j lacea	1 21	0 94	1 10	3 38	3 37	4 51	66 00	0 65	2 00	4 00	2 00	6 77	3 00
V l rama a a	3 29	1 61	1 97	7 98	7 37	6 17	42 00	2 23	3 00	9 00	3 00	10 33	3 00
V loba a	1 21	1 08	1 48	4 20	4 00	7 67	53 00	0 73	2 00	5 00	2 00	21 73	3 00
V tr cn a var *bo neac*	1 91	1 46	2 02	8 86	7 28	9 95	106 00	2 36	3 00	4 00	3 00	18 87	3 00
V tr erv a va *r ne v a*	1 60	1 30	1 97	9 40	7 90	13 33	149 00	3 40	3 00	4 00	3 00	16 50	5 00
V u bella a va *bella a*	5 25	1 39	2 91	12 56	8 21	17 91	69 00	2 85	1 00	8 00	4 00	13 27	5 00
V mbellat va *gr c l s*	1 51	1 13	1 19	6 27	3 97	4 43	59 00	1 33	1 00	4 00	4 00	10 67	2 00
V ungu c lata	5 74	3 35	3 01	11 88	8 48	13 50	66 00	5 60	0 00	4 00	0 00	14 62	2 00
V ex llat	3 43	1 39	1 62	7 20	4 30	6 25	71 00	10 57	1 00	5 00	2 00	15 38	2 00

¶ rounded off o he next nteger

ont nued

Taxa	Pod length (cm)	No of seeds pod¶	100 seed we ght (g)	Seed length (mm)	Seed width (mm)	H lum length (mm)	Yield/ plant (g)	Days to emergence¶	No of primary branches	No of lobes of terminal leaflet¶	Days to first pod maturity¶
Ne v *V g a* spec es	3 50	9 00	0 54	2 33	1 75	1 06	20 75	11 00	4 00	0 00	77 00
I aco fol a	5 60	4 00	2 00	4 16	2 08	1 58	0 28	3 00	4 00	5 00	102 00
V d el na	4 28	10 00	0 95	2 83	2 09	1 72	34 38	11 00	3 66	3 00	122 00
I glab sc n	7 70	10 00	3 17	4 31	3 08	2 51	211 12	7 00	6 00	0 00	96 00
V l ana	3 90	10 00	0 61	2 29	1 82	0 99	10 54	10 00	3 10	0 00	72 00
V kl nd le	5 70	10 00	4 10	4 40	3 46	1 52	2 81	4 00	1 00	0 00	170 00
	3 30	4 00	4 00	5 12	4 55	2 89	0 20	11 00	3 00	0 00	166 00
ɩ va *n g*	4 07	6 00	3 70	4 46	3 26	2 91	93 50	3 00	2 00	0 00	120 00
ɩ va *yl*	3 75	8 00	1 56	3 14	2 72	2 22	169 99	7 00	2 45	0 00	83 00
	8 50	10 00	6 00	5 95	4 46	2 94	0 42	8 00	3 00	0 00	184 00
a a l	5 90	11 00	2 19	3 53	2 75	1 83	80 98	6 00	2 86	2 00	57 00
l vʅ *l l ata*	4 44	11 00	0 90	2 63	2 25	1 77	39 83	9 00	3 93	2 00	77 47
va *lo a*	5 36	13 00	1 21	2 85	2 43	1 42	34 19	7 00	3 83	0 00	68 00
l a	3 19	7 00	0 76	2 47	1 88	1 13	6 60	9 00	3 67	3 00	72 00
J a	6 38	13 00	1 46	2 74	2 34	0 90	23 96	6 00	4 00	0 00	70 00
I o a a	5 17	12 00	0 86	2 67	2 00	1 52	18 16	9 00	3 31	3 00	71 00
V r va *l o eac*	5 80	12 00	1 42	3 10	2 62	1 78	45 96	9 00	3 00	2 84	84 00
V nerv a var *e v a*	6 20	13 00	1 35	3 40	2 73	1 99	16 30	11 00	3 00	3 00	169 00
V mbella a var *b llata*	8 49	8 00	5 85	7 03	3 79	3 32	92 85	4 00	2 00	3 00	87 00
V mbcllata va *g c l s*	5 25	11 00	1 10	3 21	2 25	1 53	21 11	11 00	3 00	0 00	80 00
V ng cula a	12 05	12 00	6 83	6 29	4 40	2 91	35 10	3 00	3 00	0 00	81 00
V ex ll a	9 77	12 00	1 48	4 37	2 64	2 08	6 92	9 00	3 00	0 00	95 00

¶ rounded off o he next n

as well as I respectively were yield per plant flower bud size number of lobes of terminal leaflet days to emergence and bracteole size In the case of taxa *V haimiana* and the new *Vigna* species of qualitative cluster III and falling in quantitative cluster II alone the key quantitative characters identified were number of lobes of terminal leaflet yield/plant 100 seed weight flower bud size length of keel pocket and peduncle length Similarly in the same qualitative cluster the key quantitat ve characters for the taxa *V mungo* var *sylvestris* distributed in quant tative cluster III and I are number of lobes of terminal leaflet yield/plant number of seeds/pod days to flowering 100 seed weight and days to emergence The key quantitative characters for the taxa *V n i ngo* var *mi ngo* of qualitative cluster III and distributed in quantitative clusters III and IV are number of lobes of terminal leaflet yield/plant days to emergence and length of keel pocket

The key quantitative characters ident fied for the taxa *V st pi laceae* of cluster V falling n quantitative cluster II are number of lobes of terminal leaflet y eld/plant 100 seed weight flower bud s ze length of keel pocket and peduncle length and that of *V t lobata* distr buted n quantitat ve cluster I and II were days to flowering yield/plant peduncle length number of lobes of term nal leaflet flower bud s ze and bracteole s ze Under qual tative cluster VII the key quant tative characters ident f ed for the taxa *V dalzellia a* and *V n bellata* var *grac l s* falling in quant tat ve clusters I as well as II and I respectively were days to flowering yield plant peduncle length number of lobes of terminal leaflet flower bud s ze and bracteole size and for that of taxa *V bellata* var *mbellata* falling in quant tative cluster III vere number of lobes of term nal leaflet yield/plant number of seeds pod days o flower i g 100 seed we gh and days to emergence

The key quantitative characters identified for the taxa *V vexillata* coming under qualitative cluster IX and falling in quantitative cluster V are yield per plant flower bud s ze number of lobes of terminal leaflet days to emergence and bracteole size For the taxa *V i ngi iculata* of qualitative cluster IX and belonging to quantitative cluster IV are bracteole size number of lobes of terminal leaflet yield/plant length of keel pocket days to emergence and primary leaf width

The key quantitative characters identified for the taxa viz *V khandalensis V glabrescens V aconotifolia V n ar na* and *V pilosa* which are represented by one accession each are the characters which showed the maximum coefficient of variat on in the respective quantitative clusters in which the taxa are d stributed

The percent distribution of accessions belonging to different qualitative clusters to various isozyme and molecular clusters obta ned is presented n Tables 24 and 25 respectively The distribution of selected access ons in the correspond ng quant tative clusters is also mentioned in the table n parenthesis As only dist nct morpholog cal var ants belong ng to different taxa were cons dered for isozyme and molecular study compar son w th respect to quant tative and qual tative characters may be inadequate

When clustering based on qual tative and isozyme markers are compared t was found that the accessions of taxa *V radiata* var *s blobata* fell into two dist nct clusters (I and IV respectively) S milarly the access ons of *V tri iervia* var *bo irneae* were found to be d stributed in clusters III and IV formed based on sozyme markers S milarly tl e accessions belong ng to *V t ilobata V dalzell a a* and *V i i g ci lata* were found to be d stributed n d fferent clus e s based on sozyme markers However the access ons of *V go* var *go V bell* va *g ac l s* vere fall ng nto s ngle so7yme cluster cluster I

Table 24 Homology between clustering pattern based on qual ta ve quantitative and sozyme markers

Qual tative cluster No	Total no of access ons	Taxa	No of access ons taxa wise	No of access ons selected	Isozyme clusters I	II	III	IV
					Percent distribution			
I	31	*V radiata* var *si blobata*	15	2	50 00 (QCI)			50 00 (QCI)
		V radiata var *setulosa*	6	1		100 00 (QCIII)		
		V si bramaniana	3					
		V rad ata var *rad ata*	7	1		100 00 (QCIII)		
Cluster members					25 00	50 00		25 00
II	20	*V trinervia* var *bo rneae*	19	3			66 66 (QCV)	33 33 (QCV)
		V trinerv a var *tr nervia*	1	1		100 00 (QCV)		
Cluster members						25 00	50 00	25 00
III	36	*V l a niana*	10	1		100 00 (QCII)		
		V m ngo var *sylvestr s*	22	1	100 00 (QCIII)			
		V i ungo var *m ngo*	2	2	100 00 (QCIII & IV)			
		Ne v *V gna* spec es	1	1				100 00 (QCII)
		V dalzell a a	1					
Cluster members					60 00	20 00		20 00
IV	1	*V kl andalei s s*	1					
V	16	*V st p lacea*	3	1				100 00 (QCII)
		V tr lobata	13	3	66 66 (QCI)	33 33 (QCI)		
Cluster me nbers					50 00	25 00		25 00
VI	1	*V glab escens*	1	1	100 00 (QCIV)			
VII	35	*V dalzell a a*	20	3		66 66 (QCI & V)	33 33 (QCI)	
		V bellata var *bellata*	11	2			50 00 (QCIV	50 00 (QCIV)
		I bella a va *g ac s*	4	2	100 00 (QCI)			
Clus er membe s					28 57	28 57	28 57	14 29
VIII	1	*I aco fol c*	1					

Qual tatıve cluster No	Total no of access ons	Taxa	No of accessıons taxa wıse	No of accessıons selected	Isozyme clusters			
					I	II	III	IV
					Percent d strıbutıon			
IX	7	*V vexıllata*	4	1		100 00 (QCV)		
		V ungu culata	3	2	50 00 (QCIV)	50 00 (QCIV)		
Cluster members					33 33	66 66		
X	2	*V mar na*	1					
		V pılosa	1					

QC Quantıtatıve cluster

Table 25 Homology between clustering pattern based on qualitat ve quant tat ve and molecular markers

Q ve l No	To al o of access o s	Taxa	No of access ons taxa w se	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	3	*V rad ata* var *sublobata*	15 (2)	100 00 (QCI)											
		V ra l a a var *setulosa*	6 (1)	100 00 (QCIII)											
		V subraman ana	3												
		V rad ata var *rad ata*	7 (1)	100 00 (QCIII)											
Cluste members				100 00											
II	20	*V r nerv a* var *bourneae*	19 (3)		33 30 (QCV)						33 30 (QCV)	33 30 (QCV)			
		V r nerv a var *tr nerv a*	1 (1)									100 00 (QCV)			
Clus e nembe s					25 00						25 00	50 00			
III	36	*V ha n ana*	10 (1)							100 00 (QCII)					
		V mungo var *ylvestr s*	22 (2)	50 00 (QCIII)						50 00 (QCIII)					
		V m ngo var *mungo*	2 (2)	50 00 (QCIII)					50 00 (QCIV)						
		New *V gna* spec es	1 (1)						100 00 (QCII)						
		V dalzell ana	1												
Cluster members				33 33					33 33	33 33					
IV	1	*V khandalens s*	1 (1)	100 00 (QCIV)											
V	16	*V st pulacea*	3 (1)											100 00 (QCII)	
		V tr lobata	13 (3)			33 33 (QCI)		66 66 (QCI)							

Table 25 Homology between cluster ng pattern based on qual tat ve quant tative and molecular markers

O a c cl s N	To al o f ac e o s	Taxa	No of access ons taxa w se	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Clus c be s						25 00		50 00						25 00	
VI	1	*V glabrescens*	1 (1)			100 00 (QCIV)									
VII	35	*V lalzell ana*	20 (5)	60 00 (QCI & V)	40 00 (QCI)										
		V mbellata var *mbella*	11 (2)	50 00 (QCIV)		50 00 (QCIV)									
		V mbellata var *grac l s*	4 (2)	50 00 (QCI)			50 00 (QCI)								
Cluster members				55 56	22 22	11 11	11 11								
VIII	1	*V acon t fol a*	1												
IX	7	*V vex llata*	4 (1)	100 00 (QCV)											
		V ngu culata	3 (2)	50 00 (QCIV)											50 00 (QCIV)
Cluster members				66 66											33 33
X	2	*V n ar a*	1												
		V p losa	1 (1)										100 00 (QCIV)		
Cluster members													100 00		

F gu es n the pa enthes s nd acate the number of access ons selected for molecular charcter sat on

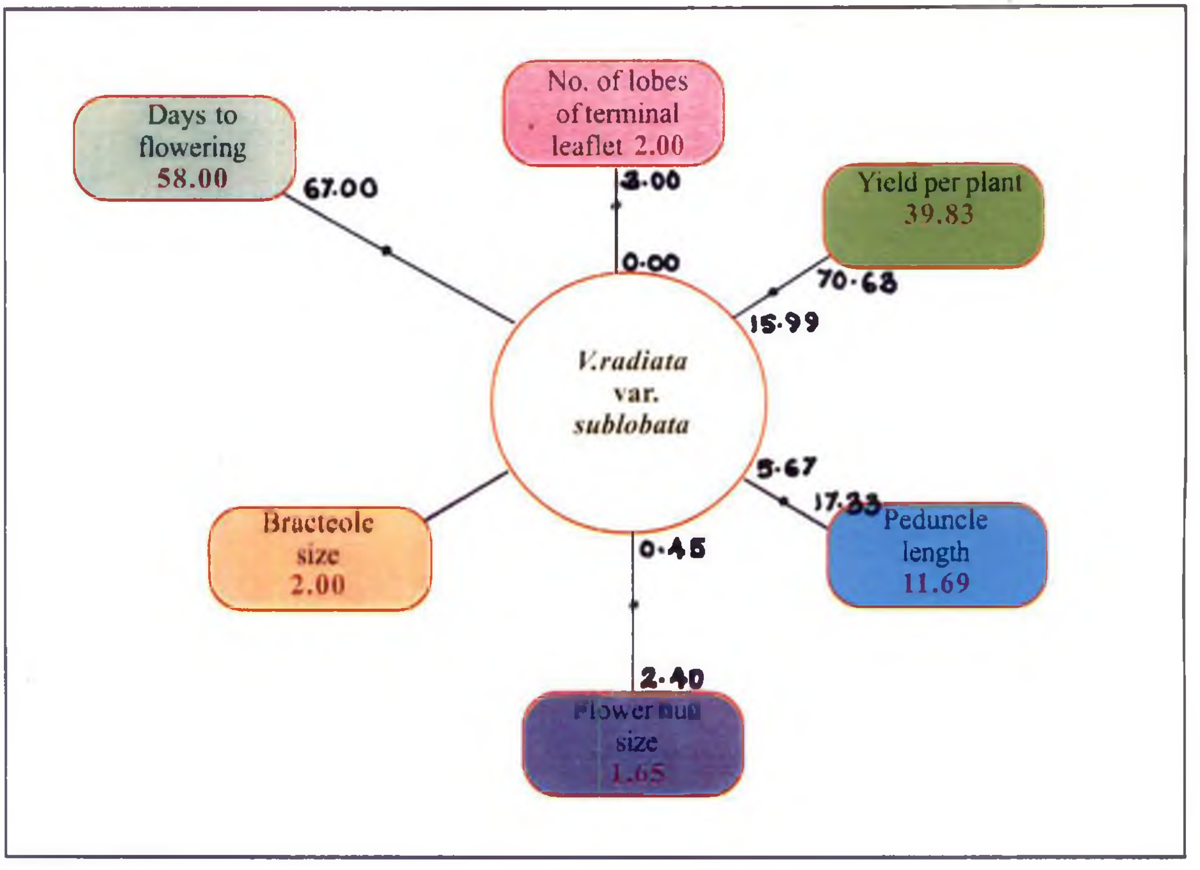
QC Quant tat ve clus er

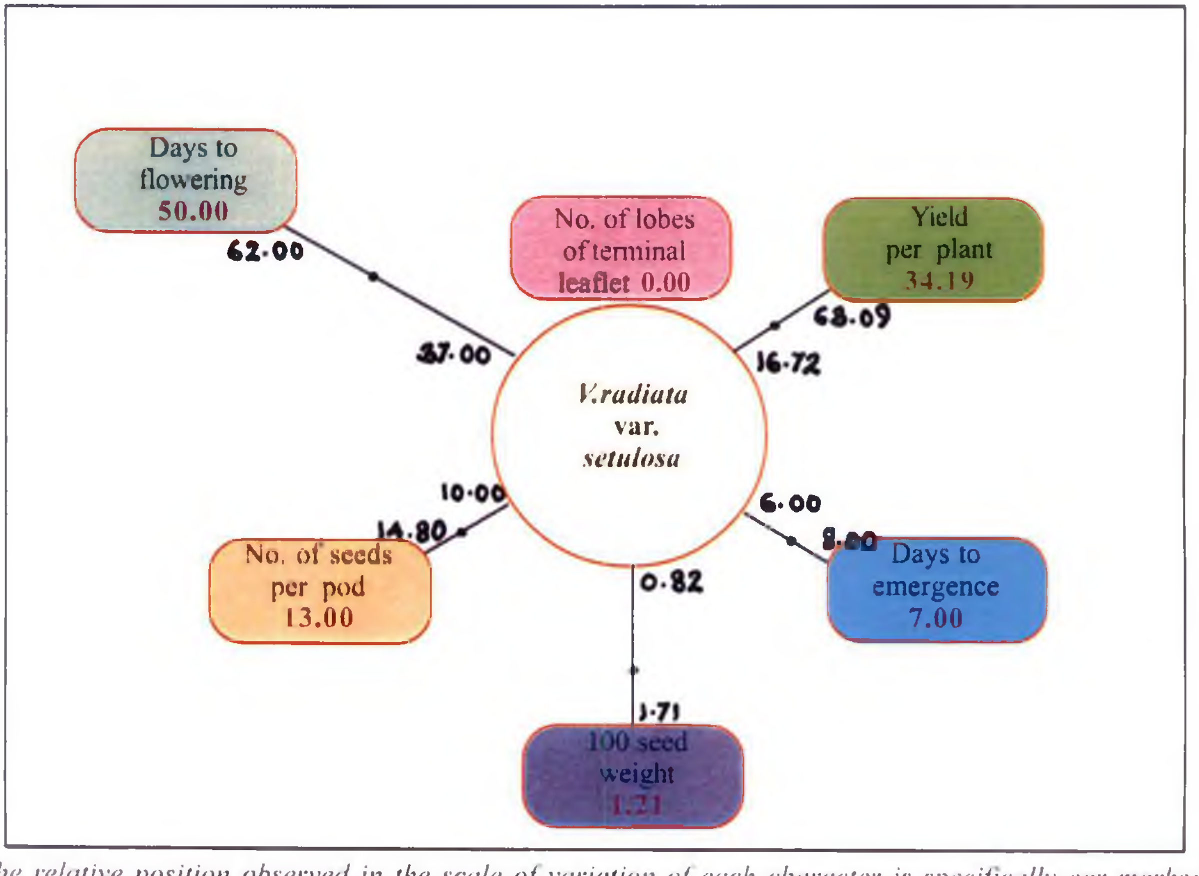
At molecular level clusterıng ıt was seen that the accessıons of taxa *V radıata* var *s ıblobata* are belongıng to the same molecular cluster However ın the case of *V trınervıa* var *boı rneae* *V mungo* var *sylvestrıs* *V mungo* var *mungo* *V t ılobata* *V dalzellıana* *V ı mbellata* var *umbellata* *V umbellata* var *gracılıs* and *V unguıcı lata* the accessıons belongıng to the same taxa were found to dıstrıbuted ın d fferent clusters at molecular level

When the dıstrıbutıon of selected accessıons ın the clusters formed based on ısozyme molecular and quantıtatıve characters vere compared t was seen that accessıons of same taxa whıch fell n same clusters based on ısozyme and molecular markers fell ın d fferent clusters based on quantıtatıve characters and vıce versa Thus the accessıons belongıng to taxa *V ı mbellata* var *ı mbellata* and *V ngı ıcı lata* fell ın dıfferent clusters formed based on ısozyme markers but fell ın same quant tatıve clusters S mılarly accessıons belongıng to taxa *V mı ngo* var *mı ngo* and *V dal ellıana* fell n same cluster that formed based on ısozyme markers but n dıfferent quantıtat ve clusters

When the dıstrıbutıon of access ons ı ı the clusters formed based on molecular markers were compared v th d stnbut on of the same ın quantıtat ve clusters accessıons belong ng to e ght taxa namely *V t ervıa* var *boı eae* *V mı go* var *sylvestr s* *V n ı ı go* var *ngo* *V tr lobata* *V dalzellıa a* *V ı mbellata* var *ı bellata* *V ı mbellata* var *g ac lıs* and *V gı c lata* fell ın same quantıtatıve clusters but ın dıfferent clusters based on molecular markers

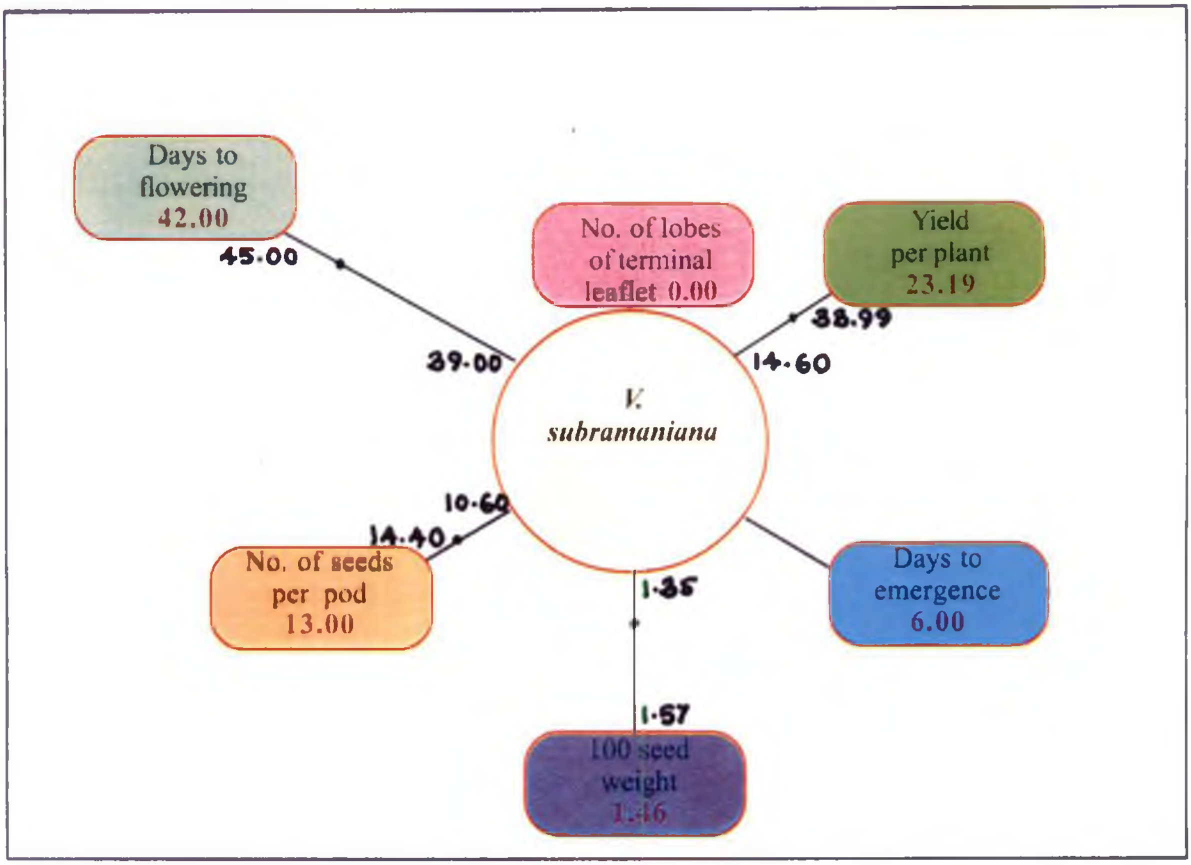
It vas also seen that the selected access ons belong ng to a s ngle taxa fell n s ı gle cluste based on ısozyme narkers but n two or three d fferent clusters formed based on nolecular narkers Thus l e access o s belong g o he taxa *V b lla a* var *g ı c l s* fell n

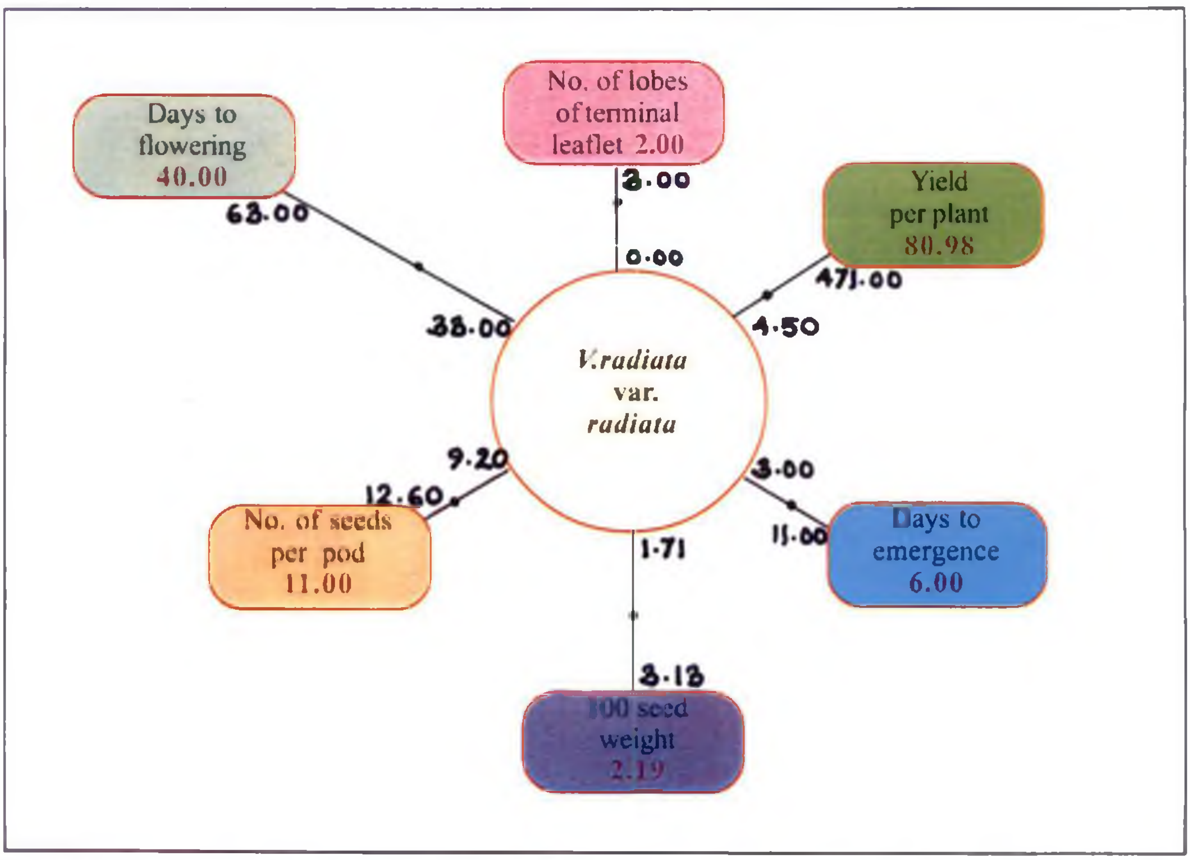




The relative position observed in the scale of variation of each character is specifically ear marked with a few exceptions where the characters are redundant.

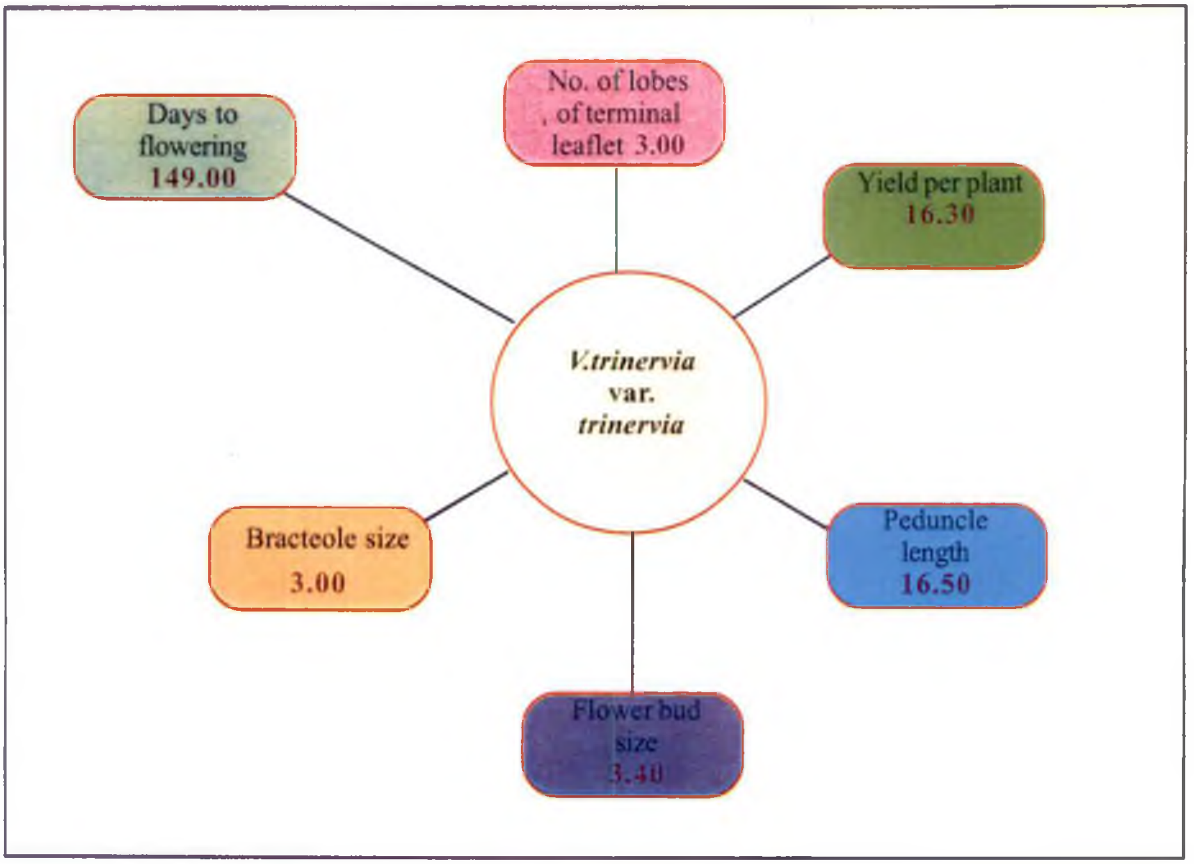
Fig.7a. Key quantitative characters of different taxa in qualitative cluster 1

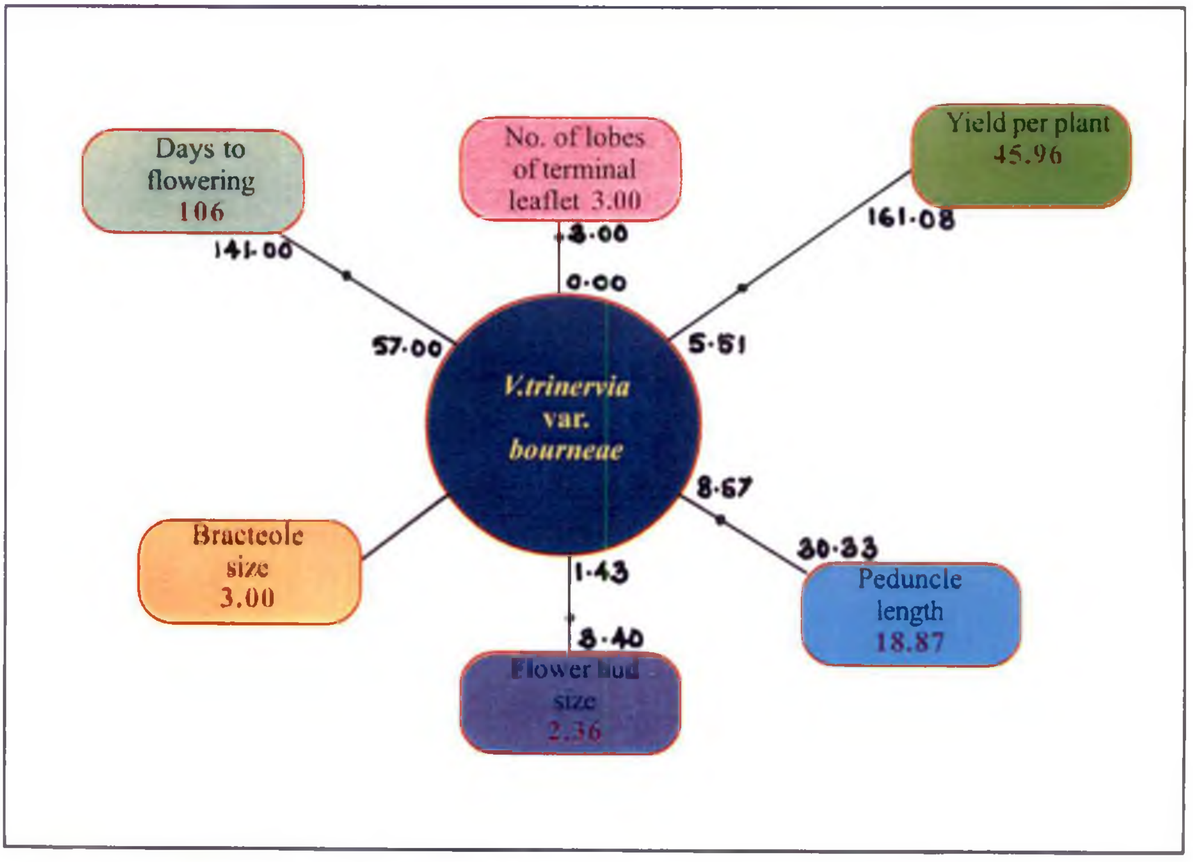




The relative position observed in the scale of variation of each character is specifically ear marked with a few exceptions where the characters are redundant.

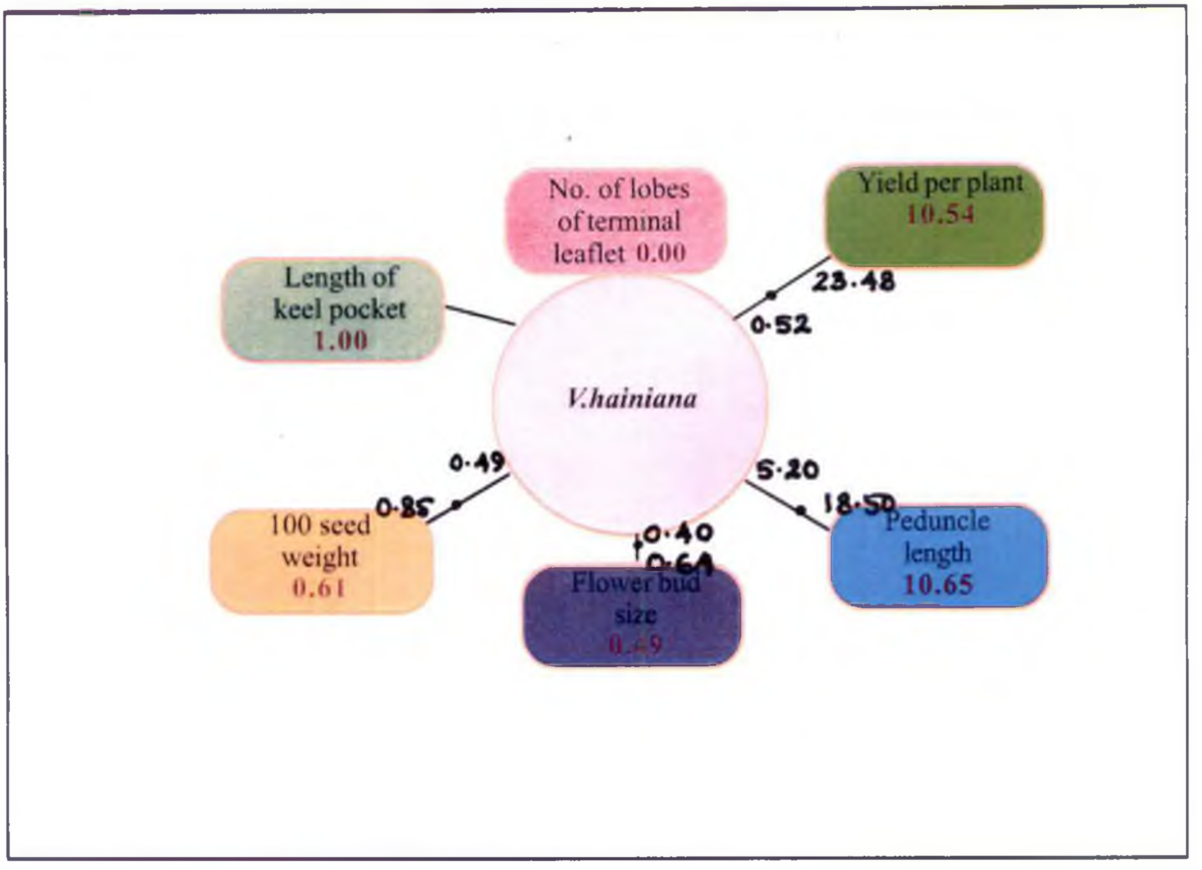
Fig.7b. Key quantitative characters of different taxa in qualitative cluster I

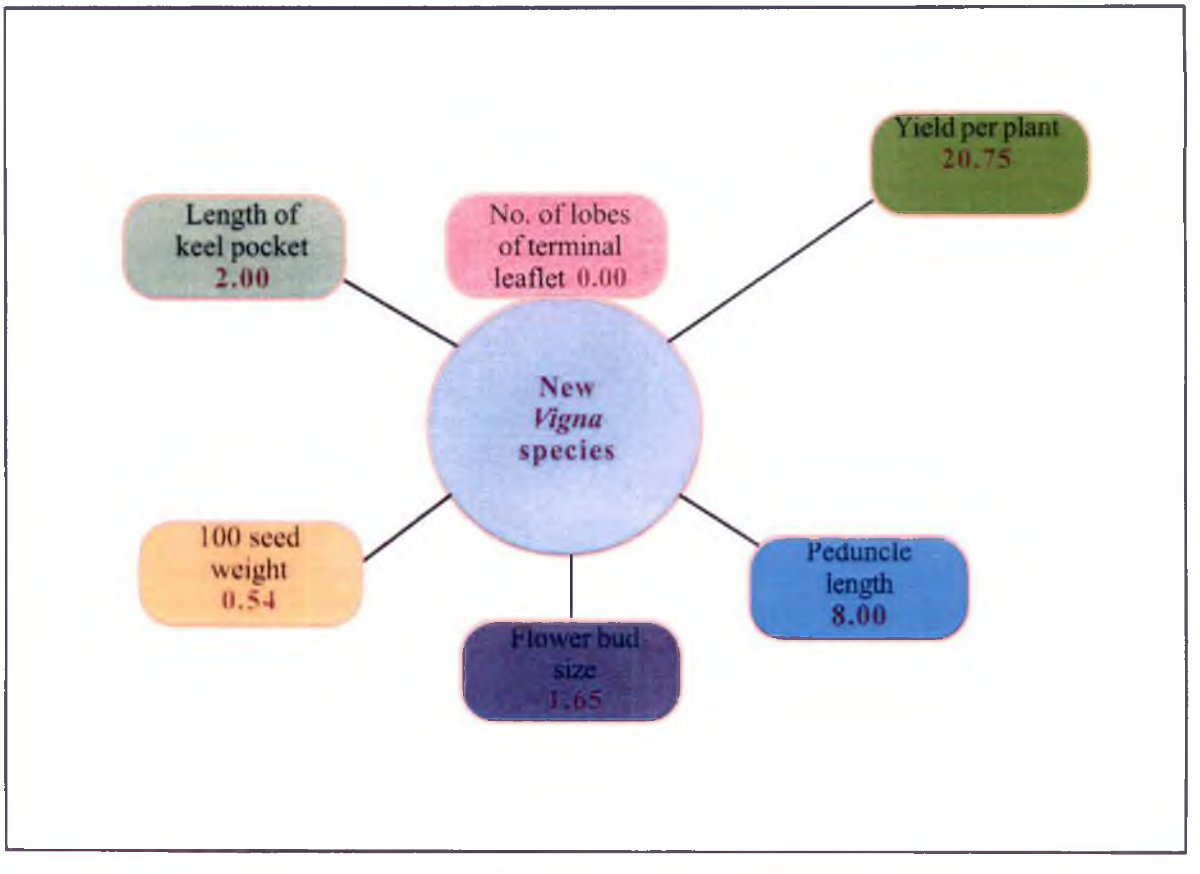




The relative position observed in the scale of variation of each character is specifically ear marked with a few exceptions where the characters are redundant.

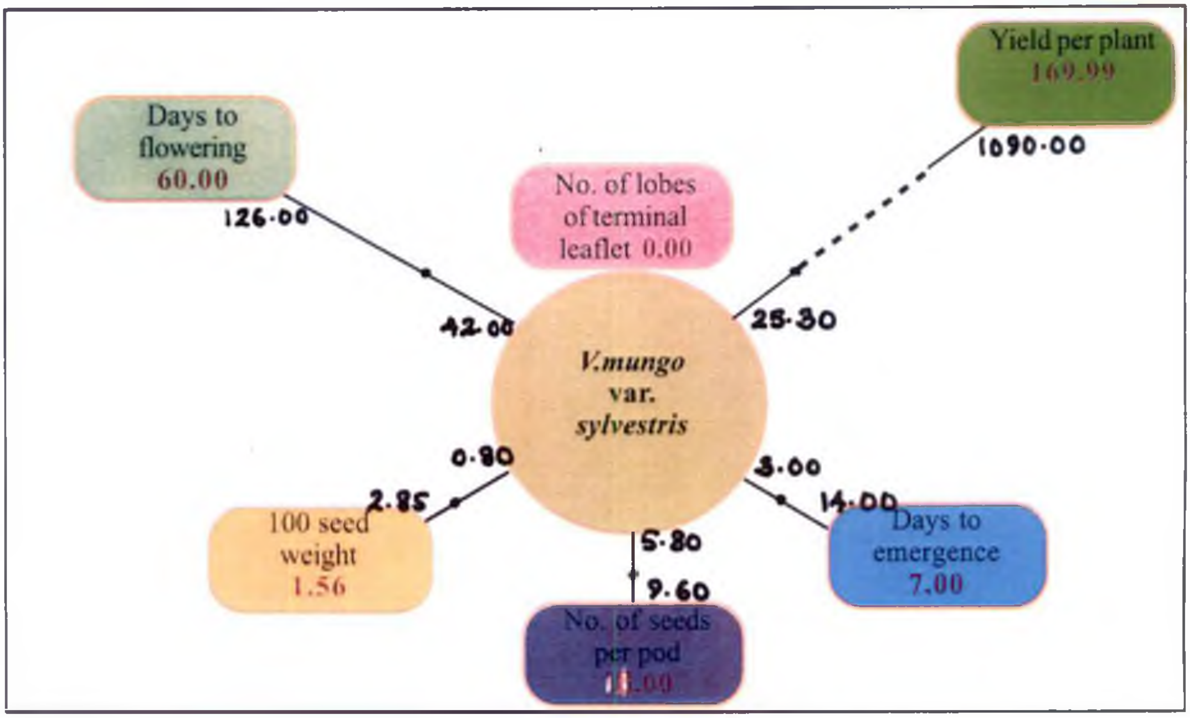
Fig.7c. Key quantitative characters of different taxa in qualitative cluster II

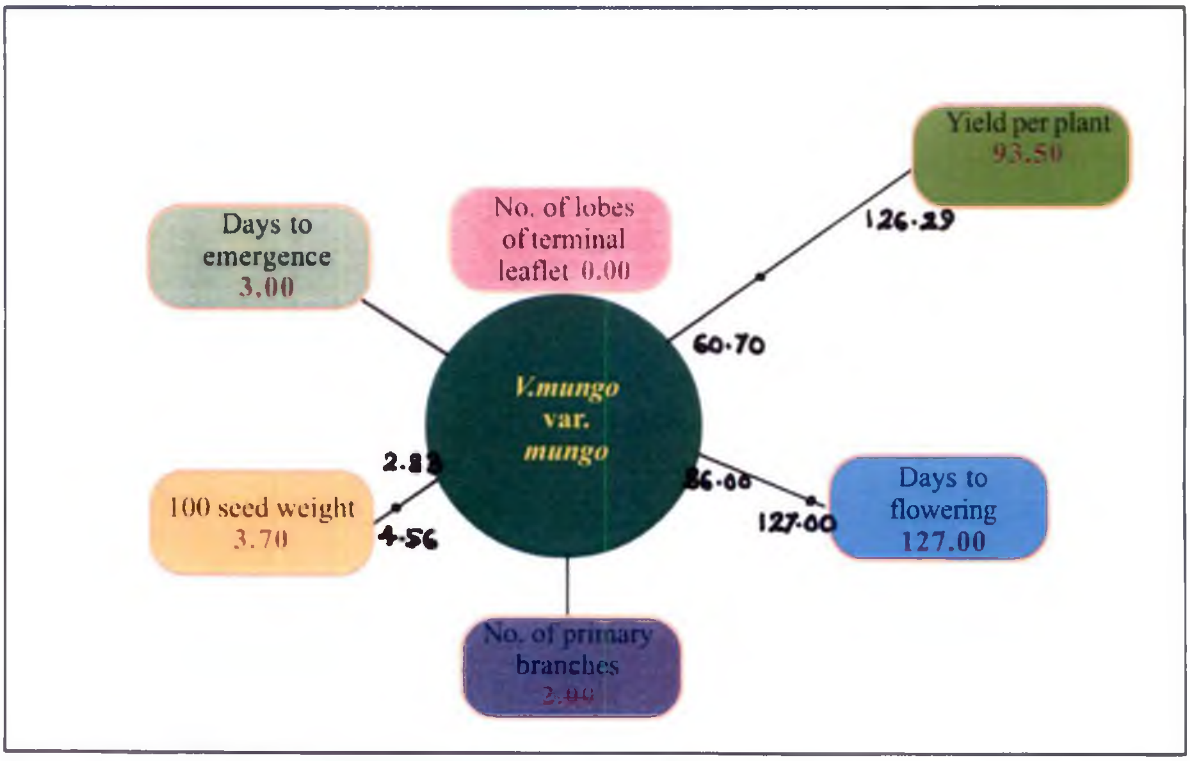




The relative position observed in the scale of variation of each character is specifically ear marked with a few exceptions where the characters are redundant.

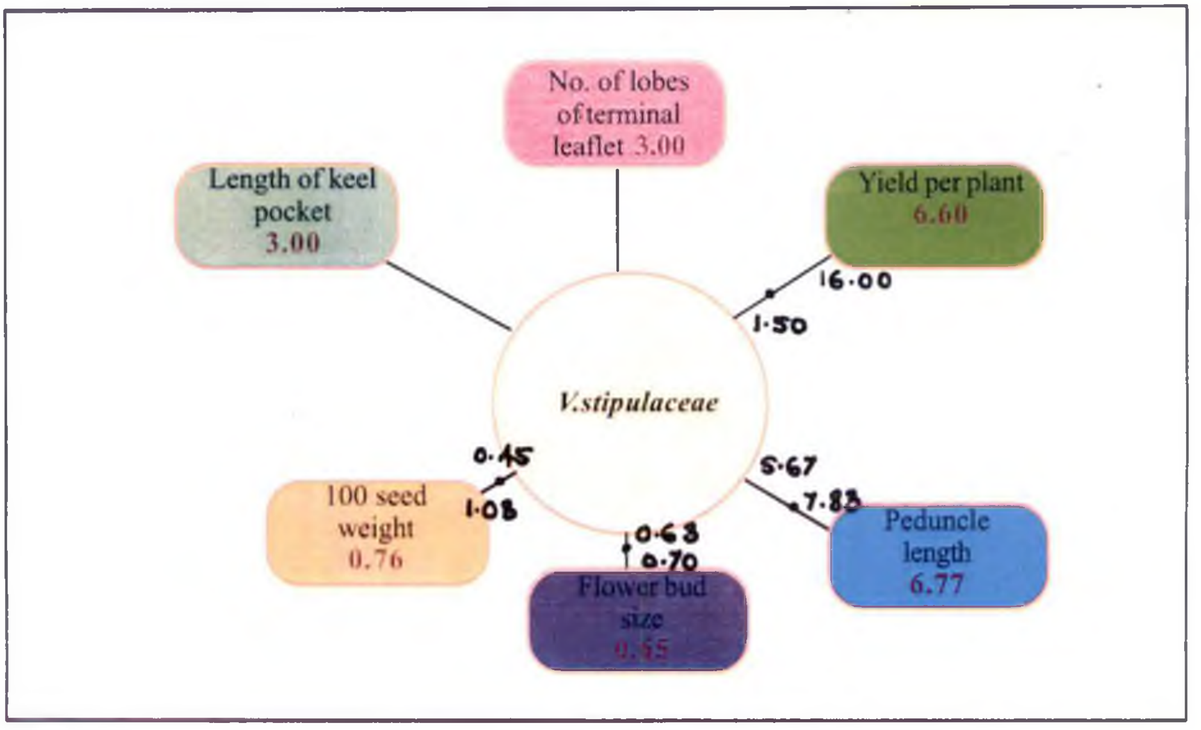
Fig.7d. Key quantitative characters of different taxa in qualitative cluster III

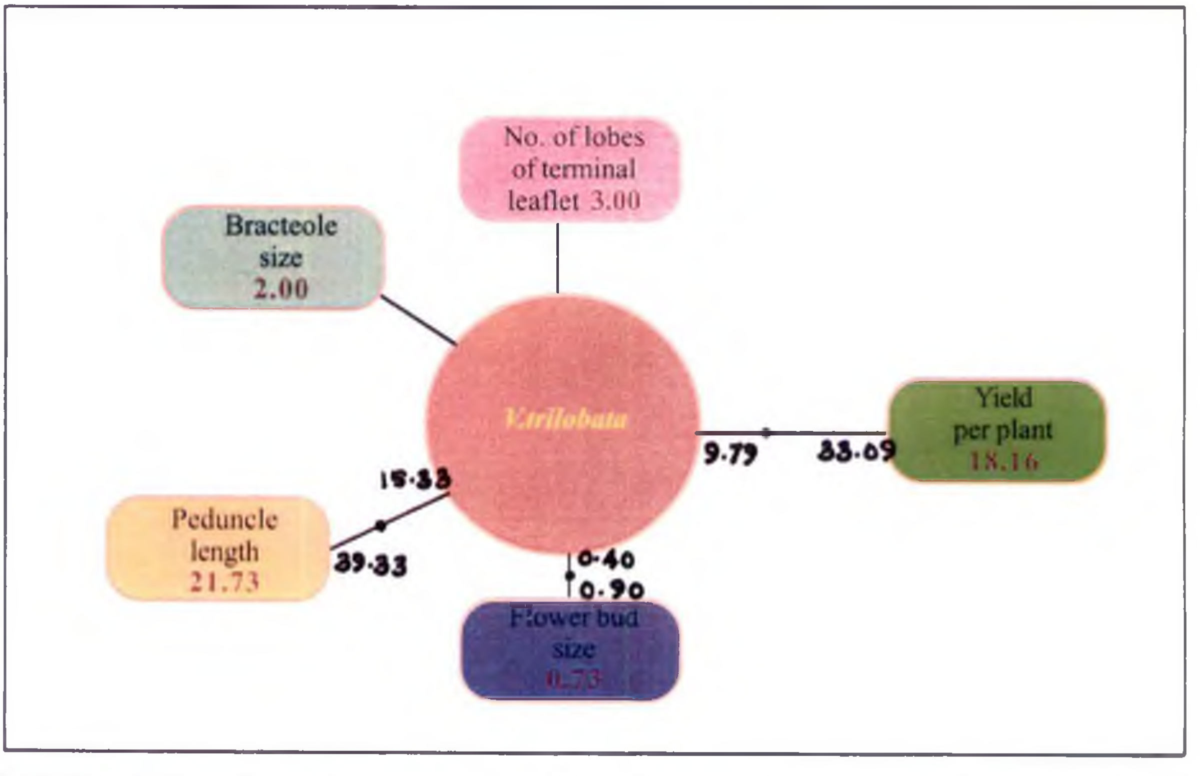




The relative position observed in the scale of variation of each character is specifically ear marked with a few exceptions where the characters are redundant.

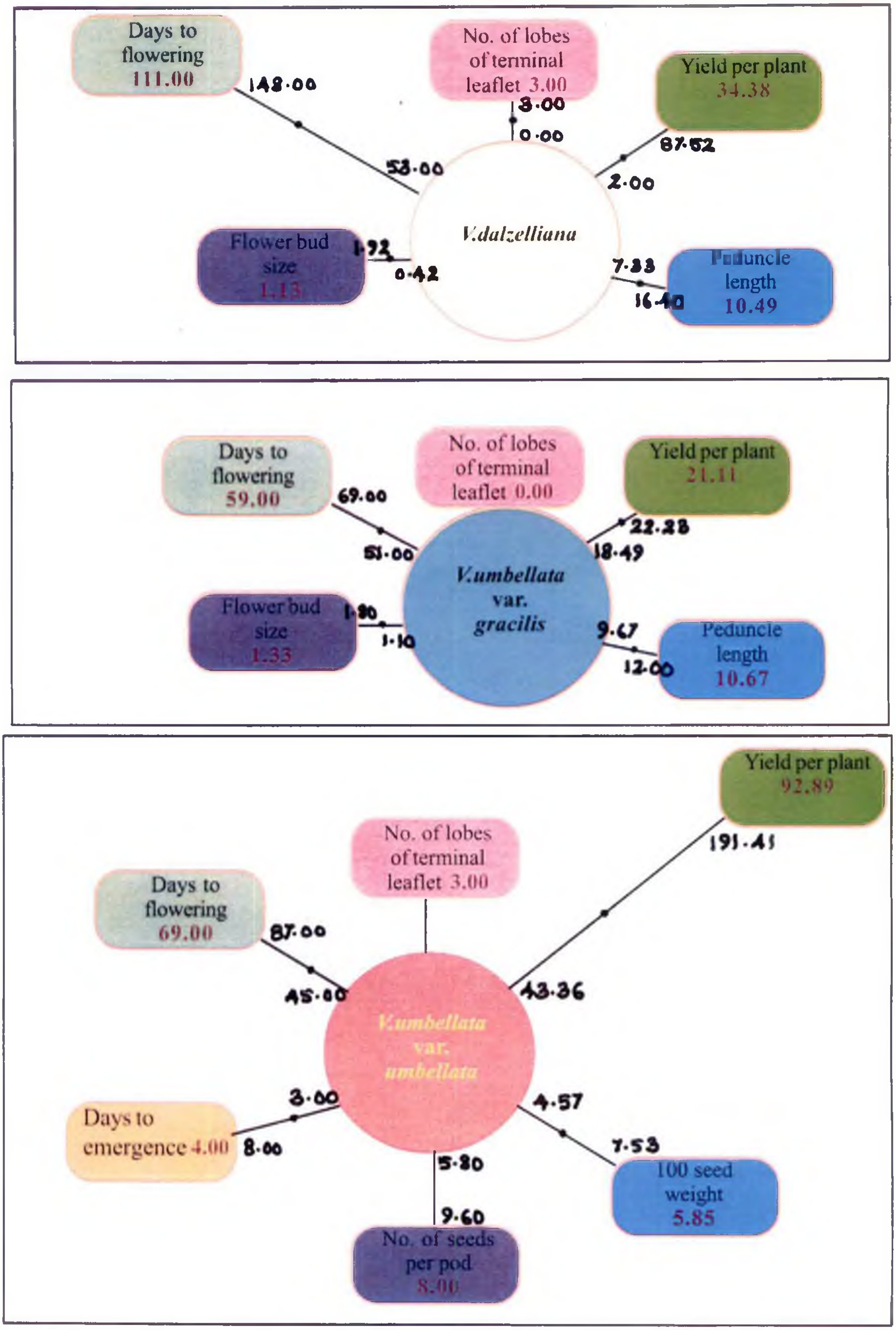
Fig.7e. Key quantitative characters of different taxa in qualitative cluster III





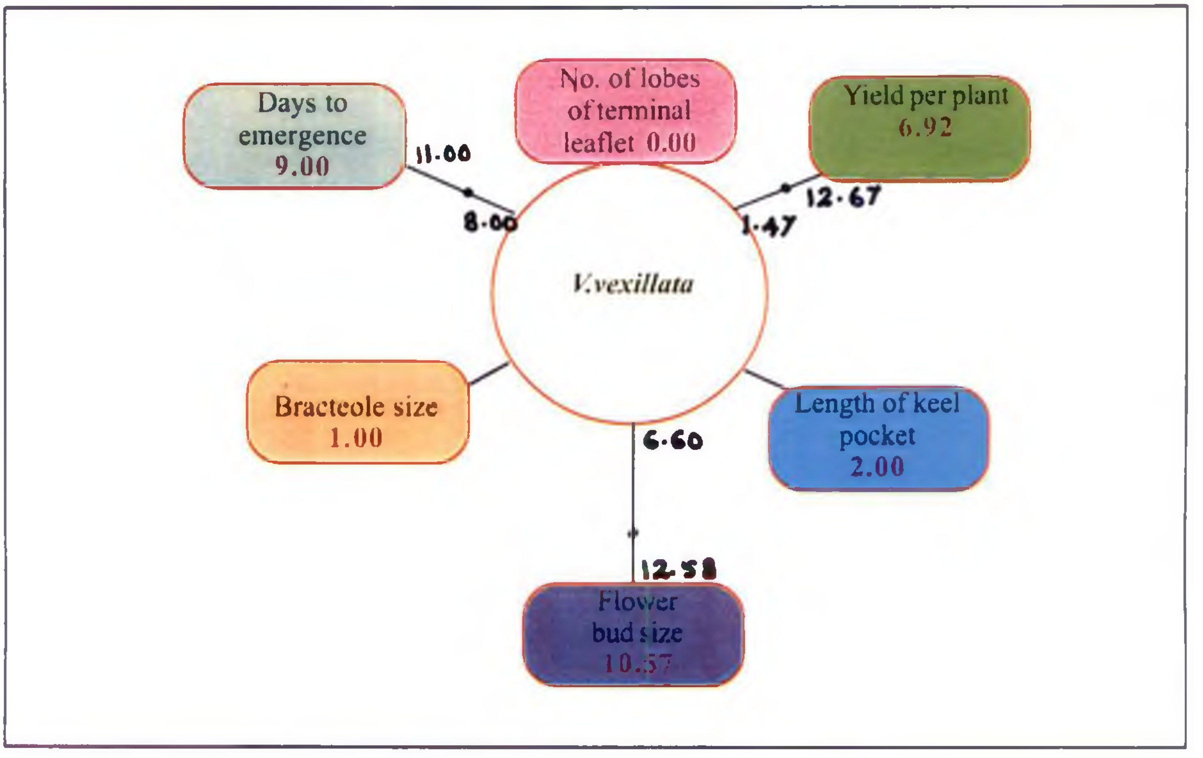
The relative position observed in the scale of variation of each character is specifically ear marked with a few exceptions where the characters are redundant.

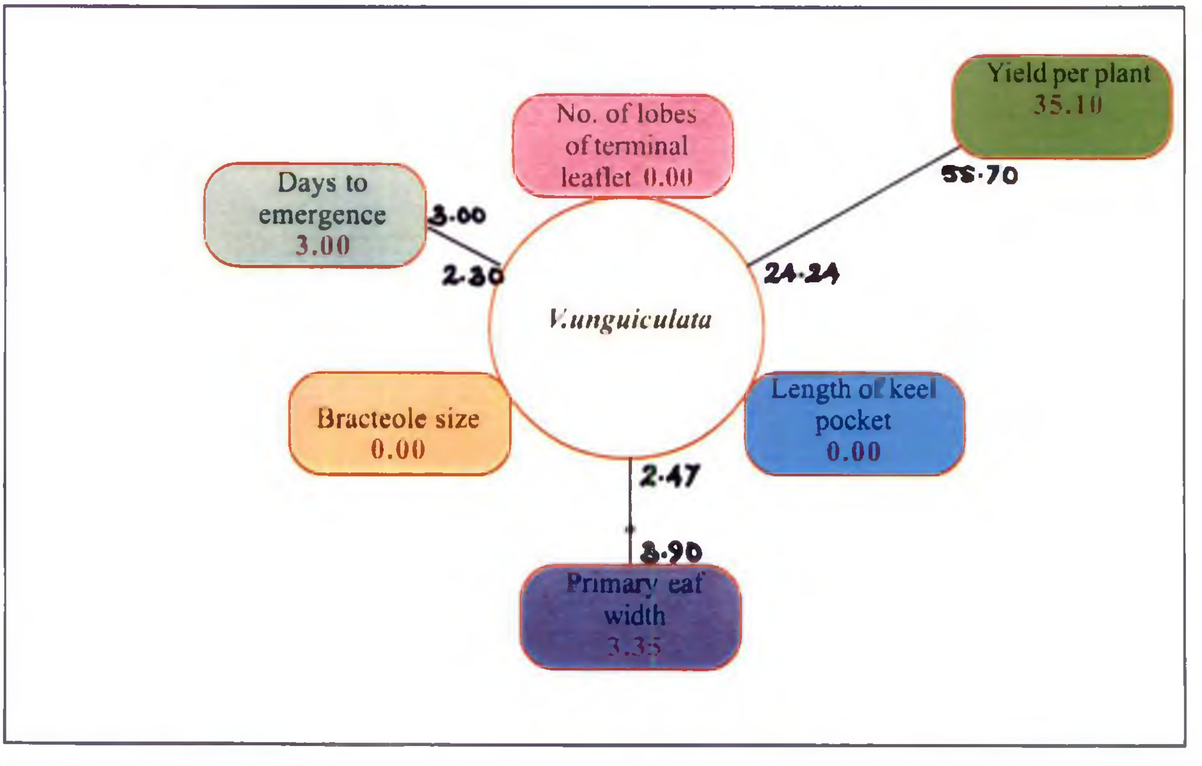
Fig.7f. Key quantitative characters of different taxa in qualitative cluster V



The relative position observed in the scale of variation of each character is specifically ear marked with a few exceptions where the characters are redundant.

Fig.7g. Key quantitative characters of different taxa in qualitative cluster VII





The relative position observed in the scale of variation of each character is specifically ear marked with a few exceptions where the characters are redundant.

Fig.7h. Key quantitative characters of different taxa in qualitative cluster IX s ngle cluster based on isozyme markers and quantitative characters but in two different clusters based on molecular markers Similarly accessions of the taxa *V radiata* var *sublobata* fell in single cluster based on molecular markers and quantitative characters but in two different clusters based on isozyme markers

Another notable deviation observed was that accessions belonging to the taxa *V mungo* var *m go* fell in single cluster based on isozyme markers but in different quantitat ve clusters Similar trend was observed in the case of *V dalzelliana* Here the accessions fell in sa ne cluster based on isozyme and molecular markers but in different clusters formed based on quantitative characters

4 5 **Key for identification of taxa**

Based on the morphological biochemical and molecular characters the following ke for dentification of *Vigna* species was developed In the key after the morphological characters the data on biochemical and molecular characters are provided for each of the spec s numerals which represents the number of polymorphic bands obtained The h ghest nu be of bands were obtained with peroxidase and UBC842 and hence taken for preparat o o l y The first figure indicates the number of bands obtained in biochemical characterizat on h peroxidase isozymes and the second by molecular characterization with primer UBC842 The characteristic features of 22 taxa of *Vigna* are presented in Plates 10 to 31

a Primary leaf attachment petiolate germination hypogeal

2a Pri nary leaf ovate lanceolate leaf unlobed or shallowly lobed keel pocket bracteole and ligule absent stipule basifixed

3a Flower blue lilac pod densely pubescent aril well developed hilum concave leaf ovate lanceolate and not round 0 5 *V pilosa*

3b Flowers yellow pod glabrescent aril not well developed hilum plain leaf round fleshy 0 0 -- *V marina*

2b Primary leaf lanceolate leaf cordate or ovate leaf lobed or shallowly lobed keel pocket bracteole and ligule present stipule peltate

4a Plant spread ng leaves deeply lobed stem and pod pubescent 0 0 *V aconitifolia*

4b Plant erect leaf unlobed stem and pod glabrescent 8 3 -- *V glabrescens*

5a Pod attachment pendent stem and pod glabrescent or sparsely pubescent bracteole minute (<0 5mm)

6a Leaf ornamentation either green or white patch present leaf lobed

7a Leaf shallowly lobed 7 9 *V dalzellia a*

7b Leaf deeply lobed presence of pinkish tinge on mature pod aril well developed 2 8 *V st p lacea*

6b Leaf ornamentation absent leaf unlobed

8a H lum concave ar l not well developed9 4 *V ι ι bellata* var *grac l s*

8b H lum convex ar l well developed 4 4 *V ι mbellata* var *ι n bellata*

5b Pod attachment horizontal stem and pod densely pubescent bracteole small (0 6 1 0mm) to med um (>1 0mm)

9a Presence of white patch on leaf dense brown short ha r on ste n and pod seed rectangular 7 7 *V t e* var *bo e e*

9b Absence of white patch on leaf dense brown long hair on stem and pod seed oblong 6 6

V trinervia var *trinervia*

1b Primary leaf attachment sub sess le germination epigeal

10a Stipule lanceolate and well developed

11a Plant not climbing

12a Plants tall erect stipule large 0 1

V khandalens s

12b Plants not tall procumbent stipule medium 8 2 *V mungo* var *mi ngo*

11b Plant climbing

13a Flower golden yellow keel pocket long seed round 8 2 *V mungo* var *sylvestris*

13b Flower greenish yellow keel pocket med um seed rectangular 6 0 *V rad ata* var *set losa*

10b Stipule ovate and not well developed

14a Flower yellow keel pocket minute (<0 1mm) pod glabrescent leaf densely pubescent 7 7

V ha nia ia

14b Flower green sh yellow or pale yellow keel pocket med um (0 2 0 3mm) pod moderately pubescent

15a Plant erec seed rectangular 7 2

V rad ata var *rad ata*

15b Plant climbing

16a Bracteole lanceolate peduncle glabrescent pod attachme it horizontal pendent absence of d st nct p nk spot on the t p of

KERALA AG UL U A U
K A U
NT AL
LB ARY
PO THR SUR

young pod 0 0

V subramanıana

16b Bracteole ovate peduncle moderately pubescent pod attachment horızontal dıstınct pınk spot on the tıp of young pod 9 0 —

-- *V radıata* var *sı blobata*

17a Germınat on hypogeal prımary leaf attachment sub sessıle 6 26 *V vexıllata*

17b Germınatıon epıgeal prımary leaf attachment petıolate

18a Flower vıolet pod long anl well developed 8 8

V unguıcı lata

18b Flower yellow pod short anl not well developed

19a Pr mary leaf cordate wıth cuneate tıp leaves ovate shallow to deeply lobed 9 8

V t lobata

19b Prımary leaf ovate lanceolate leaves ovate lanceolate unlobed 4 3 *Vıgna* spec es *ıova*

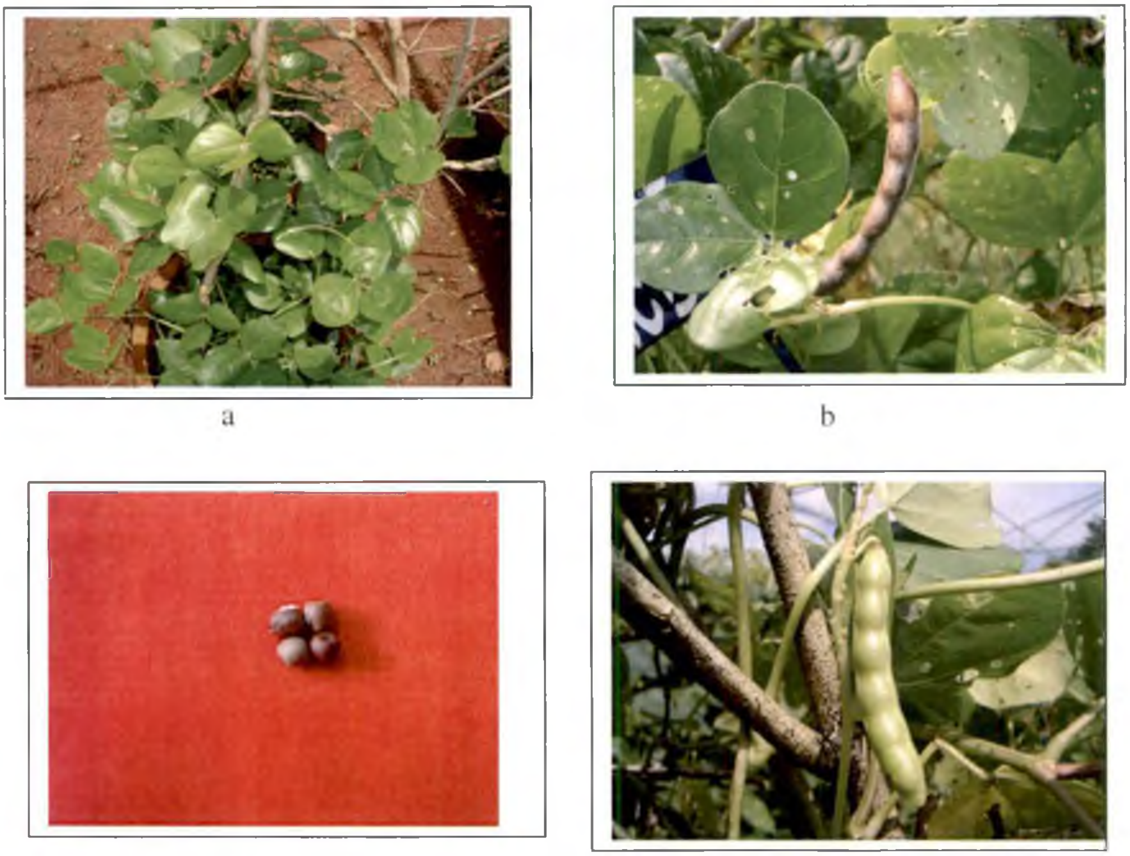
a

b

c

Plate 10. *V.pilosa*

a. Plant habit
b. Primary leaf
c. Seeds



a b c d

Plate 11. *V.marina*

a. Plant habit
b. Dry pod
c. Seed
d. Mature pod

a

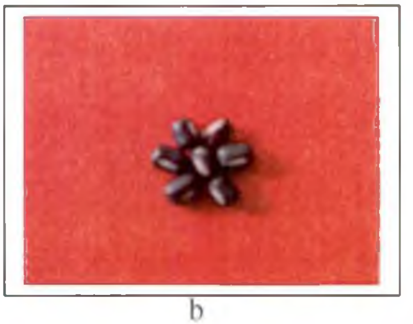
b

c

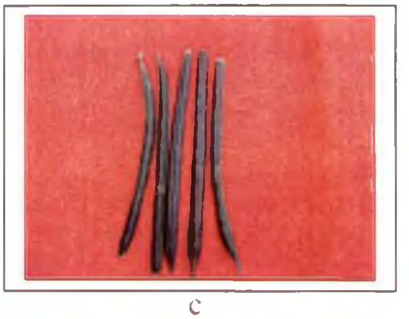
Plate 12. *V. aconitifolia*

a. Plant habit
b. Primary leaf
c. Seed

a



b



c

Plate 13. *V. glabrescens*

a. Plant habit
b. Seed
c. Dry pod

Plate 14. *V.dalzelliana*

a. Plant habit
b. Primary leaf
c. Flower
d. Immature pods
e. Dry pods
f. Variability in seeds of different accessions

Plate 15. *V.stipulaceae*

a. Plant habit
b. Primary leaf
c. Flower
d. Leaf ornamentation
e. Dry pods
f. Variability in seeds of different accessions

a

b

c

f

e

d

Plate 16. *V. umbellata* var. *gracilis*

a. Plant habit
b. Primary leaf
c. Flower
d. Immature pod
e. Dry pods
f. Seed

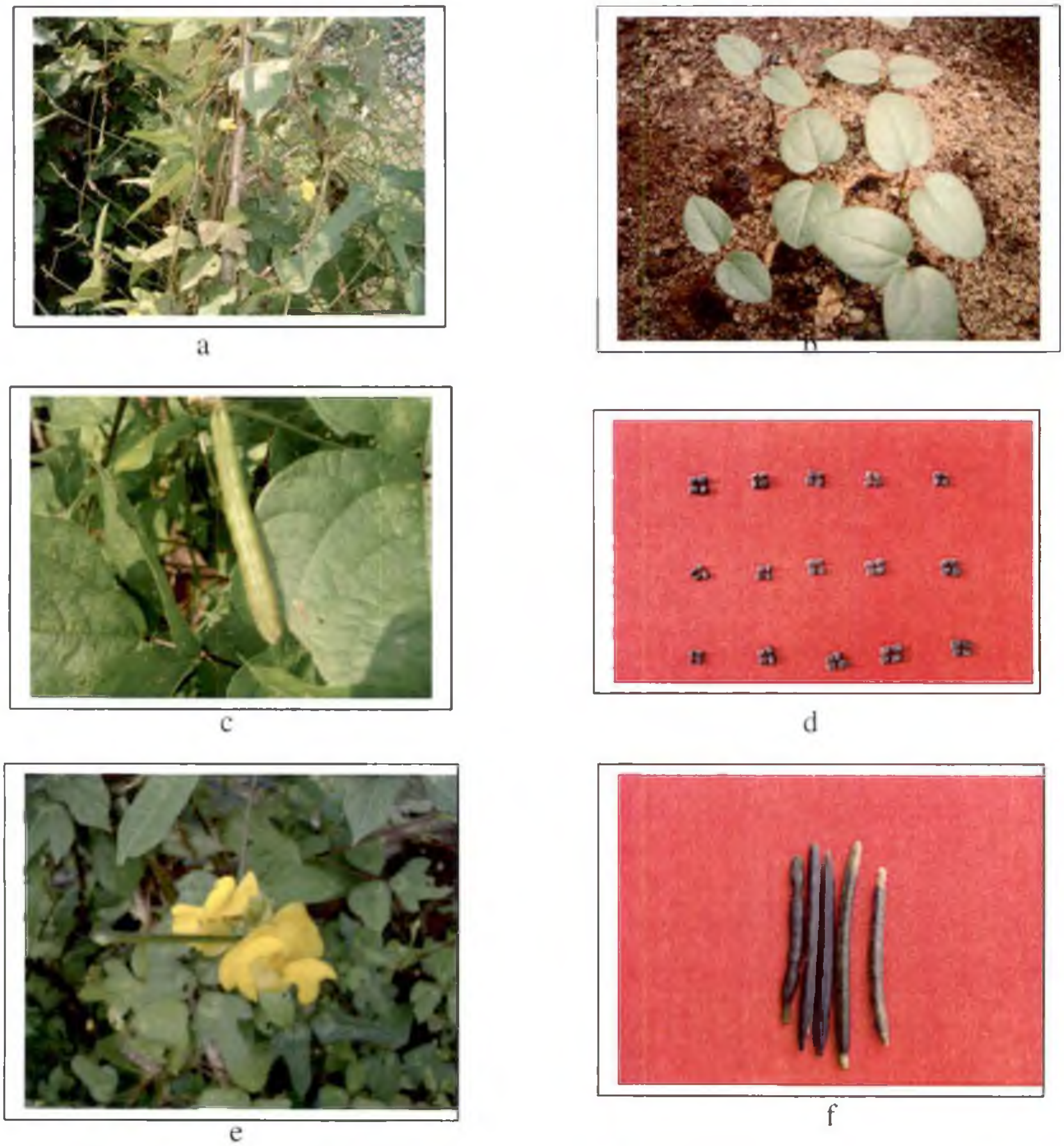
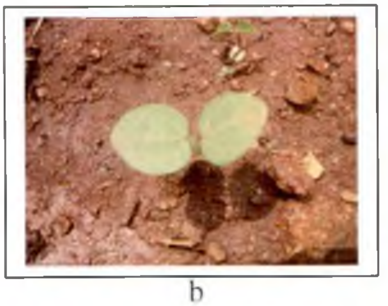


Plate 17. *V.trinervia* var. *bourneae*

a. Plant habit
b. Primary leaf
c. Immature pod
d. Variability in seeds of different accessions
e. Flower
f. Dry pods

a



b

c

Plate 18. *V.trinervia* var.*trinervia*

a. Plant habit
b. Primary leaf
c. Seeds

a

b

c

e

d

f

Plate 19. *V.umbellata* var.*umbellata*

a. Plant habit
b. Primary leaf
c. Flower
d. Immature pod
e. Dry pods
f. Seed variability of different accessions

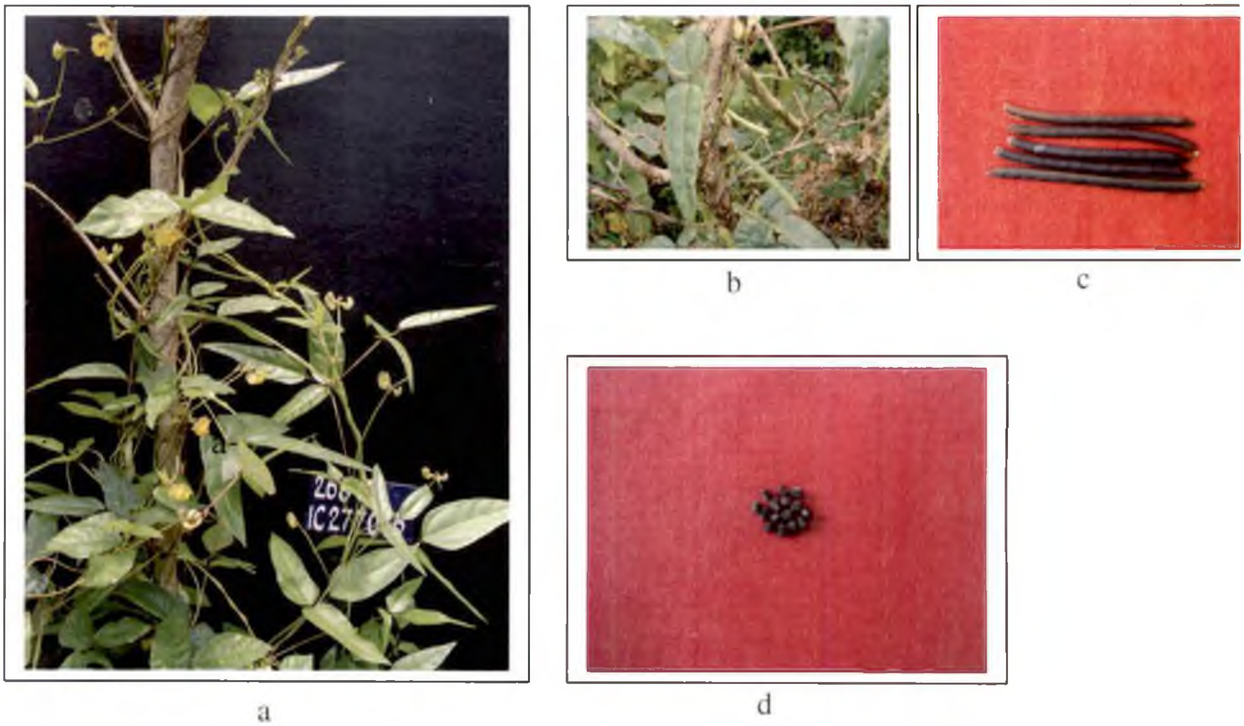


Plate 20. *Vigna* species nova

a. Plant habit
b. Immature pod
c. Dry pod
d. Seed


a


b

Plate 21. *V.khandalensis*

a. Plant habit
b. Leaf

a

b

c

e

Plate 22. *V. mungo* var.*mungo*

a. Plant habit
b. Primary leaf
c. Immature pods
d. Variability in seeds of different accessions

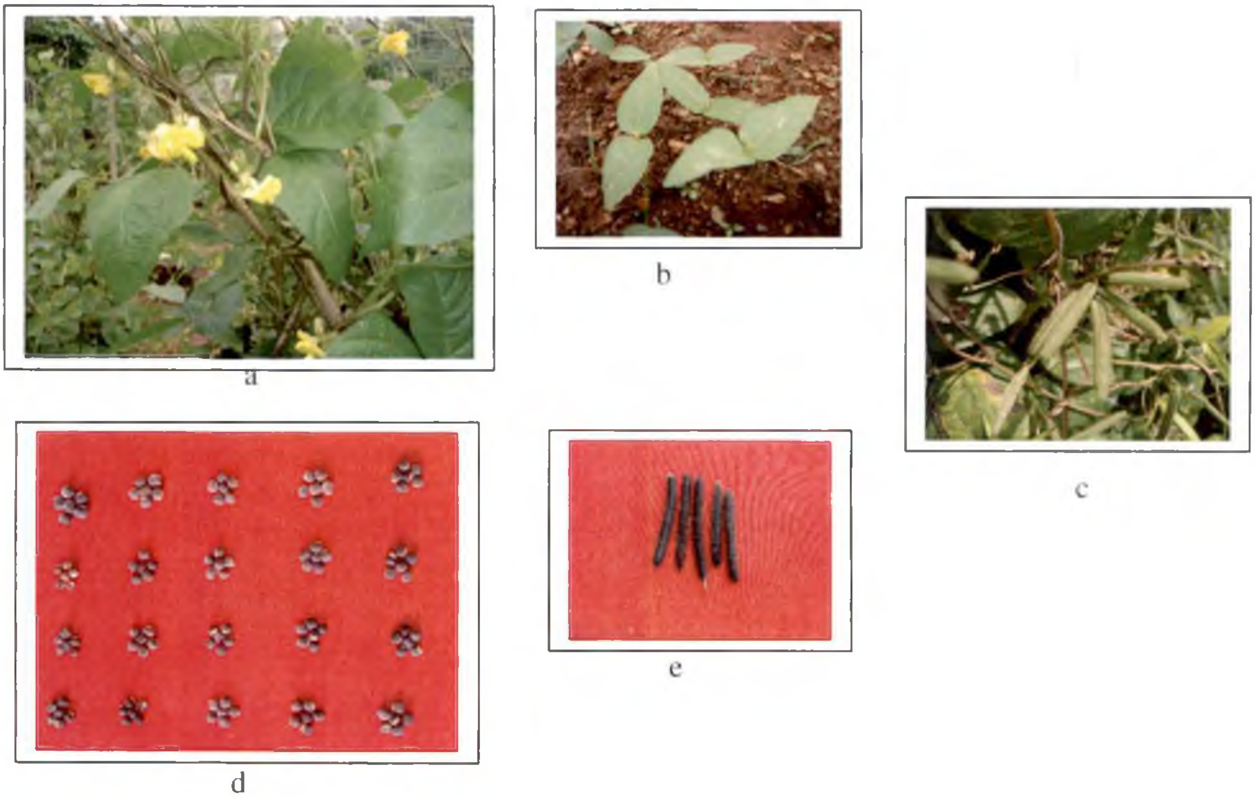


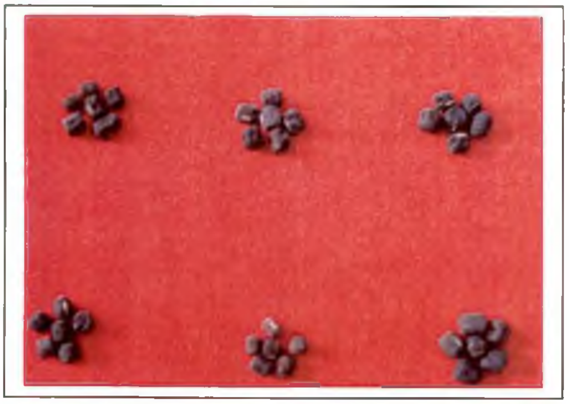
Plate 23. *V.mungo* var.*sylvestris*

a. Plant habit
b. Primary leaf
c. Immature pods
d. Variability in seeds of different accessions
e. Dry pods

a

b

c



d

Plate 24. *V.radiata* var.*setulosa*

a. Plant habit
b. Primary leaf
c. Dry pods
d. Variability in seeds of different accessions

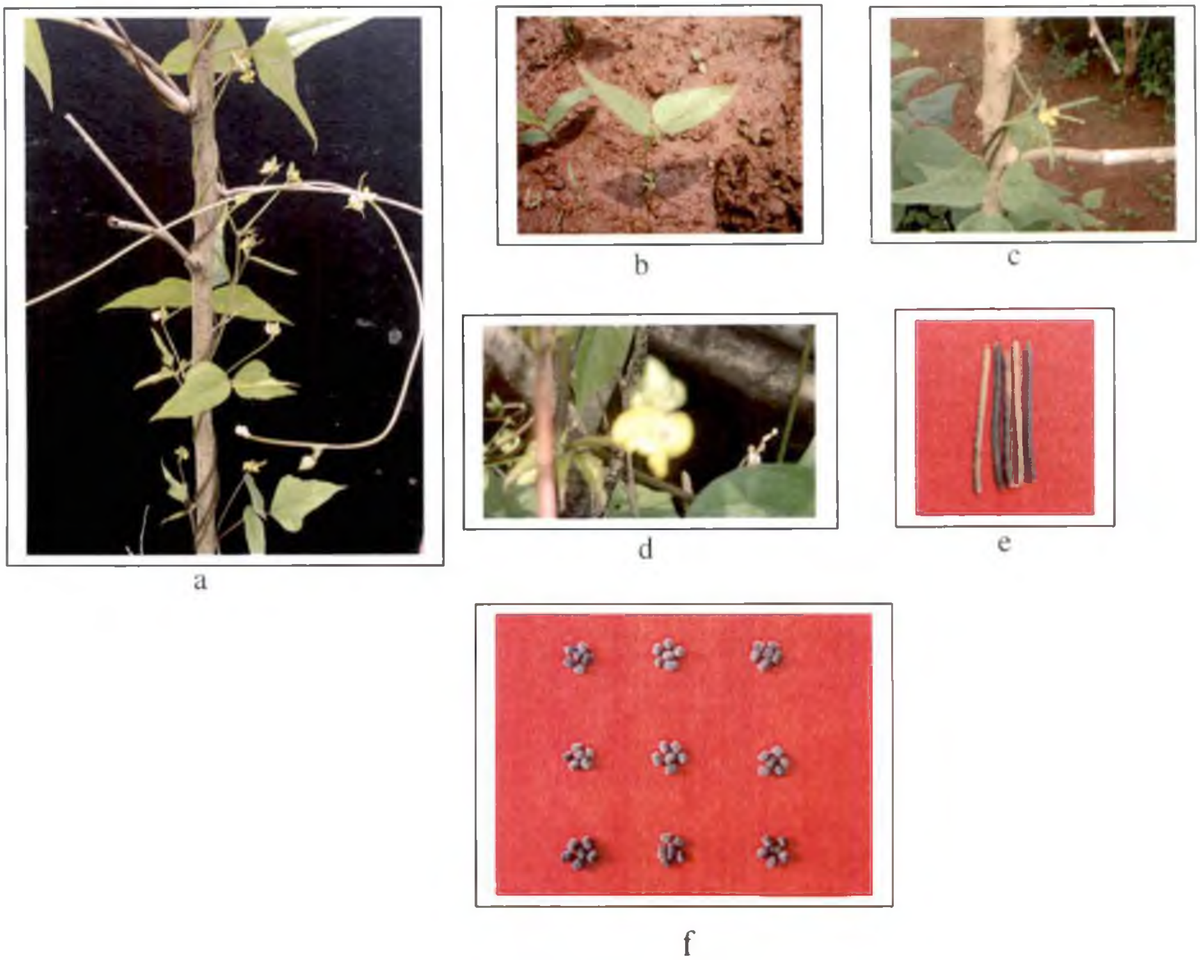


Plate 25. *V. hainiana*

a. Plant habit
b. Primary leaf
c. Immature pods
d. Flower
e. Dry pods
f. Variability in seeds of different accessions

a

b

c

d

Plate 26. *V.radiata* var.*radiata*

a. Plant habit
b. Primary leaf
c. Dry pods
d. Variability in seeds of different accessions

a

b

Plate 27. *V.subramaniana*

a. Plant habit
b. Primary leaf

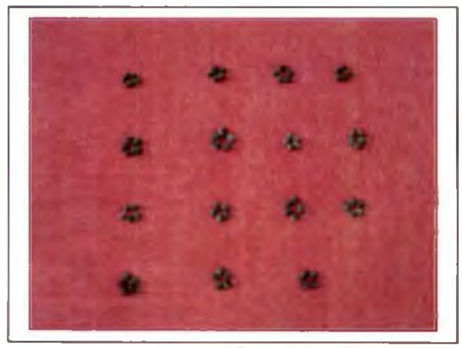
a

b

c

d

e



f

Plate 28. *V.radiata* var.*sublobata*

a. Plant habit
b. Primary leaf
c. Immature pods
d. Leaf variability
e. Mature pod
f. Variability in seeds of different accessions


a


b


c


d


e

Plate 29. *V. vexillata*

a. Plant habit
b. Primary leaf
c. Flower
d. Dry pods
e. Variability in seeds of different accessions

a

b

c

Plate 30. *V.unguiculata*

a. Primary leaf
b. Dry pods
e. Variability in seeds of different accessions


a


b


c


d

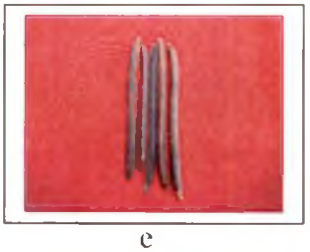

e

Plate 31. *V.trilobata*

a. Plant habit
b. Primary leaf
c. Immature pods
d. Variability in seeds of different accessions
e. Dry pods

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Discussion

Discussion

5 Discussion

The genus *Vigna* is one of the largest groups in leguminoseae The three major pulse crops grown in India namely green gram black gram and cowpea belong to this genus The other minor pulses cultivated in India belonging to this genus are jungle bean rice bean and moth bean The wild species of these pulses are also found to occur in India (Arora 1985) Though several authors have reported the occurrence of wild species a consolidated list of *Vigna* species occurring in India and the taxonomical identity of some species are still confusing Hence morphological characterisation combined with biochemical and molecular characterisation was done to identify the different species and also to understand the species relationships in *Vigna*

5 1 Morphological characterisation

The 150 accessions of *Vigna* species were evaluated based on various qualitative and quantitative characters Variability was observed among the 150 accessions in various qualitative morphological characters Based on these qualitative characters the accessions were regrouped into 22 taxa Of the 22 taxa listed 17 taxa comprising of 140 accessions belonged to sub genus *Ceratotropis* or Asiatic *Vigna* The remaining five taxa comprising of 10 accessions belonged to sub genus *Vigna* and *Plectotropis* (Table 8)

Depending on the germination behaviour and the nature of attachment of primary leaves the 22 taxa of *Vigna* were classified into four different types They were (Plates 1a to 1c)

Type A Epigeal and petiolate

Type B Epigeal and sub sessile

Type C Hypogeal and petıolate

Type D Hypogeal and sub sessıle

The seedlıng characters were specıfic for dıfferent sectıons ın sub genus *Ceratotropıs* The taxa belongıng to sectıon *Aconıtıfolıae* exhıbıted type A and type C characters The eıght taxa comıng under the sect on *Ceratotropıs* showed type B nature All the taxa under sectıon *Angulares* exhıb ted type C nature The taxa belongıng to sub genus *Vıg a* exhıb ted type A and type C nature The only specıes whıch showed type D nature was *V vexıllata* whıch belonged to the sub genus *Plectotropıs* Baudoın and Marechal (1988) Tomooka *et al* (2003) and Bısht *et al* (2005) had also reported the classıficatıon of Asıatıc *Vıg a* specıes based on seedlıng characterıst cs The new *Vıgna* taxa showed Type A nature as ın the case of taxa belong ng to *Aconıtıfolıae* sectıon But thıs accessıon dıffered from other taxa of *Aco t folıae* sect on n glossy and unlobed nature of leaves glabrescent plant type and pod characters

Morpholog cal evaluatıon revealed tl at ornamentat on on surface of leaf was also a dıstıı c character for dıfferent at ng specıes or dıffeıent var et es wıtl n the same specıes Ornamentatıon of the leaf helped to d fferentıate *V st pı laceaea* from *V tr lobata V tr erv a* var *bo neae* from *V trınerv a* var *tr ne v a* and *V dalzell a a* from *V ı bellata*

Attachment of stıpule was peltate n all the taxa belongıng to sub genus *Ceı atot op s* but bas fixed ın all the taxa belongıng to other sub genera Sım larly the flower colour ranged from yellow to shades of yellow ın all the members of sub genus *Ce atotrop s* Baudo n and Ma echal (1988) Tomooka *et l* (2003) and Bısht *et ıl* (?005) also reported peltate stıpule and yellow flowers n Asıatıc *V g a* taxa

All tl 24 quant tative characters evaluated exhib ted high coefficient of variation nd ca g the m er se variability available in these taxa with respect to these characters (Table 10) Though here was no significant variability in the length of keel pocket the presence r absence of keel pocket played an important role in distinguishing the different taxa ncluded n h s dy (Plate 5) The keel pocket was absent in all the taxa belonging to sub genus *I gna* Ho ever in *V vexillata* belonging to the section *Plectotropis* a minute keel pocke vas observed The keel pocket was prominent in all the species belonging to sub genus *Ce a op* The presence of keel pocket as a key morpholog cal character for Asiat c *V g a* wa a so l cr bed by Tateishi and Ohashi (1990) and Tomooka *et al* (2003)

5 1 1 Cl is er alysis based on qualitative characters

Cluster a al s s based on 47 qualitat ve characters revealed that the access ons b l nging t 27 axa fell nto 10 different clusters at 60 percent similarity The taxa belong ng o *Ce op s* sect on of sub genus *Ce atot op s* were found to fall nto three d s c cl cluster I III and IV The accessions belonging to *V adiata* var *ad ata* *I d a a olo* *V ad ata* var *seti losa* and *V s b a a a* were fall ng n clus er I Tl e acc s o s b long ng to *V haimiana* *V m ngo* var *mi go* *V m go* var *sylvestris* and the ne v *V g pe s* vere fall ng n cluster III *V kha dale s s* alone was found to fall n clus e I (T bl 11) The taxa within each cluster were closely related The new *Vig a* s] l *C tot op s* group and was found to be more closely related to *mi ngo* o ex an *ad at i* *V kl a dale isis* belong ng to the same sub genus formed a distinct I v also *V kl i dale s s* was dist nct fro n all the other taxa of *V g a* by b ge fol aceous st pules and broad leaflets Ho veve t resemb ed a c l nd po l cl aracters S n ilar resul s ve e reported n he stud es conducted by earlier workers in *Vigna* species (Maekawa and Shidei 1955 Baudet 1974 Jaasaka and Jaasaka 1990 Lawn 1995 Kaga *et al* 1996 Tateishi 1996 Tomooka *et al* 2003 Bisht *et al* 2005)

When the taxa belonging to section *Angulares* were examined the accessions fell in three distinct clusters (clusters II VI and VII) The accessions of *V trinervia* var *bourneae* and *V trinervia* var *trinervia* were found to fall in cluster II The accessions of *V dalzelliana* *V umbellata* var *umbellata* and *V umbellata* var *gracilis* were falling in cluster VII *V glabrescens* alone was found to go into cluster VI It can be seen that the position of both taxa of *V trinervia* (*V trinervia* var *trinervia* and *V trinervia* var *bourneae*) is in between *radiata* and *mungo* group of *Ceratotropis* section This is in contrast to the report given by Bisht *et al* (2005) They have reported that the *V trinervia* formed a distinct group and was intermediate between *Ceratotropis* and *Angulares* sections Moreover there is no authentic report of occurrence of *V trinervia* var *trinervia* in India This species has so far been reported as *V bourneae* only The only one accession of *V glabrescens* included in the present investigation formed a separate cluster (cluster VI) in between *V trilobata* and *V dalzelliana* sections of *Ceratotropis* This species is probably an amphidiploid reported to be combining the genomes of *V radiata* and *V umbellata* (Dana 1964) However based on rDNA sequence *V glabrescens* had been shown to be a derived from *V umbellata* and *V angularis* (Goel *et al* 2001) It is an annual robust herb with erect growth habit large golden yellow flowers and green glabrescent long pods

Accessions belonging to *V trilobata* and *V stipulacea* of section *Aconitifoliae* were falling into same cluster (cluster V) and which was placed in between *Ceratotropis* and *Angulares* section The only accession of *V aconitifolia* remained as a distinct cluster (cluster

VIII) and was observed to be closely associated with *V umbellata* group The closeness of these two taxa and the placement of *Aconitifoliae* section in between *Ceratotropis* and *Angulares* were also reported by Bisht *et al* (2005) and Tomooka *et al* (2003) Like *V trinervia* an authent c report on occurrence of *V stipulaceae* m Ind a is not there so far *V stipi laceae* is found to occur in Srilanka (Tomooka *et al* 2003) A live plant of this particular accession of *V st pulaceae* (Vst3) was collected from sandy beach of Kanyakumari district of Tamil Nadu by NBPGR The seeds of this accession might have been dispersed through water and got established in the sandy beach of Kanyakumari Probably a first report on occurrence of *V stipulaceae* in Ind a w ll emerge from this study

The taxa belonging to sub genus other than *Ceratotropis* namely *V pilosa* *V marina* *V vexillata* and *V ι ngι ιcι lata* formed two distinct clusters (cluster IX and X) Of these access ons of *V vexillata* and *V ι ngι ιcι lata* were coming in the same cluster (cluster IX) indicat ng a close relationsh p bet veen them *V vex llata* resembled *V ι gι c lata* in features like long pods (>8cm) and large pea like flo vers *V pilosa* endemic to Western Ghats vas seen to be morphologically distinct with ts pale v olet pea like flowers dense pubescent pods and absence of bracteoles and keel pocket *V n ar ı a* is another un que taxa occurring in islands of Andaman and N cobar and Lakshadweep

5 1 2 Cluster analysis based on quantitative characters

The clustering based on quant tat ve characters resulted in five clusters (Table 12) In quant tative clustering the accessions belonging to single taxa were fall ng n two or more quant tat ve clusters This indicated that thougl the access ons of same taxa were s m lar in qual tat ve tra ts they vere distinct n quant tat ve features

The quantitative cluster I included the maximum number of accessions Eight different taxa belonging to different sections of sub genus *Ceratotropis* were included in this cluster The maximum cluster distance was observed between cluster I and IV (Table 13) indicating that the taxa belonging to these clusters were distinct m quantitative characters *V radiata* var *radiata* *V radiata* var *sublobata* *V dalzelliana* *V trilobata* and *V umbellata* var *gracilis* falling in cluster I were distinctly different from *V khandalensis* *V pilosa* *V glabrescens* and *V umbellata* var *umbellata* falling in cluster IV This is also confirmed by the distinct morphological features of these taxa The smallest inter cluster distance between clusters I and II indicated the close relationship among the taxa (*V radiata* var *radiata* *V radiata* var *sublobata* *V dalzelliana* *V trilobata* and *V umbellata* var *gracilis* *V aconitifolia* *V hainiana* *V marina* and *V stipulacea*) falling into these clusters

5 1 3 Storage pest study

The present study showed bruchid infestation ranged from 0 100 percent among the accessions (Table 14) From this t is clear that the resistance sources for bruchid beetles are available in the evaluated taxa irrespect ve of whether wild or cultivated The individual access ons belonging to each taxa are hence to be considered for identification of resistant sources The differences in the level of resistance observed among the accessions of the same taxa may be due to intra specific variation or due to the presence of different strains of bruchid beetles Wild *Vigna* taxa were reported to be the source of resistance to bruchid beetles by Tomooka *et al* (2000) Lambrides and Imrie (2000) had identified 3 accessions of *V adiata* var *sublobata* as resistant to bruchid beetles Tomooka *et al* (1992) had also developed a res stant source by backcrossing *V radiata* var. *sublobata* with *V adiata* Hence su table breedıng programmes can be employed for developıng resıstant types usıng the resıstant sources avaılable ın d fferent taxa of *Vıgna*

5 1 4 Study of pollen morphology

Pollen graıns of all the taxa evaluated were found to be monads trızonoporate obtuse and convex However there exısted sıgnıficant dıfferences among the accessıons ın sıze of pollen gra ns thıckness of exıne shape sculpturıng and nature of spınes on the exıne *V vex llata* had the b ggest pollen graın followed by *V ı ngı ıculata* and *V pılosa* *V vexıllata* pollen graıns could also be dıstınguıshed by the scabrate sculpturıng (Table 15 and Plates 6a and 6b) Nyananyo (1990) and Edeoga and Gomına (2001) had utılızed pollen attrıbutes such as pos tıon of furrows pollen wall morphology symmetry shape and sıze of pollen graıns as maın characters of taxonomıc value ın establ sh ng relatıonshıps among the taxa However the results of the present study are not ın full agreement wıth that report

5 2 Bıochemıcal characterısatıon

The clusterıng pattern based on ısozyme study us ng dıstınct accessıons belong ng to d fferent *V gna* taxa vas dıfferent from the pattern formed based on morpholog cal characterısatıon (Table 17) Each cluster formed based on sozyme analysıs ncluded accessıons belongıng to d fferent sub genera The As atıc and non Asıatıc *Vıg a* taxa were grouped nto same cluster as aga nst the morpholog cal characterısatıon (qualıtatıve and quantıtatıve clusterıng) Th s ınd cated that the dıvers ty ın *V gna* taxa based on ısozyme markers s very low Thıs s n contrast to the results reported by Sehgal and Chandel (1992) a d Selv *et al* (2003) They suggested tl at sozymes w th hıgh level of polymorph sm were effect ve tools for d vers ty analysıs n *V g a* taxa The sozymes used n he present study perox dase and poly phenol ox dase ere polymorphıc Though the sozymes sho ved polymorphism the results were not in agreement with those reported by Sehgal and Chandel (1992) and Selvi *et al* (2003) Hence it is suggested that more isozymes showing still higher levels of polymorphism may be used for characterisation of taxa of *Vigna*

5 3 Molecular characterisation

The 33 distinct accessions selected from different taxa of *Vigna* for molecular evaluation fell into 12 clusters Among these 33 accessions 15 accessions were included in cluster I The 15 accessions in cluster 1 belonged to all sections of *Vigna* except *Aconitifoliae* The three accessions of section *Aconitifoliae* included in this study fell into three different molecular clusters (clusters III V and XI) indicating the difference among these accessions at molecular level The remaining 15 accessions were falling into 9 separate molecular clusters as evident from Table 19 Hence all the accessions falling into same qualitative clusters have to be taken for molecular characterisation rather than distinct variants alone The result of the present study are in agreement with the results reported by Ajibade *et al* (2000) Tomooka *et al* (2001) Doi *et al* (2002) and Saravanakumar *et al* (2004) in *Vigna* species using molecular markers

5 4 Comparison of different clustering patterns

The number of clusters formed based on qualitative characters and quantitative characters were different The clustering based on qualitative characters and quantitative characters grouped the 150 accessions into 10 and 5 clusters respectively The relationship among the taxa was explained more logically at 60 percent similarity in clustering based on qualitative characters The differences among different taxa falling in the same qualitative cluster can be further explained when quantitative traits are also considered A comparison of the two clustering patterns was done by finding out percent distribution of accessions of each taxa ın a qualıtat ve cluster ınto dıfferent quant tatıve clusters Majorıty of access ons of each taxa ın a sıngle qualıtatıve cluster fell ınto a sıngle quantıtatıve cluster ındıcatıng the sımılarıty among these accessıons at quantıtatıve level also The remaınıng accessıons of these dıfferent taxa ındıcated that though these accessıons appeared to be sımılar at qualıtatıve level they are dıfferent at quant tatıve level However the accessıon Vd16 of *V dalzellıana* whıch devıated from the other accessıons of the same taxa at qualıtatıve level belonged to same cluster as others at quantıtat ve level Th s poınts to the need of subjectıng thıs accessıon to further study

Usıng the key quantıtat ve characters ıdent fed a statıstıcal key was also developed for dıstınguıshıng the d fferent taxa of *Vıgna* The key quantıtatıve characters ıdentıfied for each taxa are represented ın Fıgure 7a to 7h

The selected accessıons from varıous taxa used for sozyme and molecular analysıs grouped nto four and twelve clusters ın respectıve clusterıng patterns When a comparıson was made among the qualıtatıve sozyme and molecular clusterıng patterns t was seen that the accessıons whıch belonged o the same qual tatıve clusters behaved dıfferently a sozyme and molecular levels Hence the ntra specıfic varıab lıty avaılable ın each taxa at ısozyme and molecular levels should also be consıdered ın crop mprovement programs

The d stınct on between accessıons was much more evıdent wıth molecular rather than wıth sozyme markers Hence to obta n a stıll more clear pıcture about the relatıonshıps among the access ons of d fferen t *V g a* taxa all 150 accessıons are to be subjected to molecular characterızat on

5 5 **Key for ıdentıficatıon of taxa**

Unknown taxa can be ıdentıf ed wıth already known herbarıum specımen ut lızıng the avaılable lıterature and comparıng the descrıptıon of unknown taxa wıth publ shed descrıptıon Taxonomıc keys prove an ıdeal tool for rapıd ıdentıficatıon of unknown taxa Keys are very convenıent relıable and quıck to use Based on the arrangement of characters and theır utılızatıon keys are of two types sıngle access (dıchotomous dıagnostıc or sequent al) or multı access (polyclaves) keys In thıs study based on the 72 descrıptors studıed 18 sımple d chotomous taxonomıc keys were ıdentıfied to dıstınguısh 22 taxa of *V gna* Unl ke earlıer keys descrıbed to dentıfy *Vıgna* taxa here the keys prov ded are based on characters rangıng from germınatıon behavıour to pod and seed characters as well as the bands obta ned ın ısozyme and molecular analys s Earl er Babu *et al* (1985) Dana and Karnakar (1990) and Tomooka *et al* (2003) had developed dıchotomous keys to ıdentıfy few *V gna* specıes

5 6 **Future lıne of work**

The present research work ıncluded both cult va ed and v ld taxa of *V g a* and tl e relat onshıps among the 22 taxa were expla ned The cultıvated taxa namely *V ad ata* var *ad ata V n go* var *ı ıgo V ı mbellata* var *ı n bellata V aco t fol a V ı g c lata* and *V t ılobata* could be mproved for y eld by utılızıng the respect ve w ld taxa ın breedıng programmes For utılız ng these wıld taxa crossabılıty relatıonshıps among the taxa need to be establıshed The crossabılıty relatıonsh ps can be utılızed to group the taxa nto d fferent gene pools Access ons dent f ed as res stant sources for bruch d nfestat on can be ut l zed ın breed ng programmes for transfer of res stance nto cul vated varıety Ano her mportant aspect hat needs thrus s screen ng of *V g a* access ons ın endem c areas for yello v ı osa c virus (YMV) resistance The identification of res stant sources for YMV would be a tremendous break through in the research field of genus *Vigna*

The biochemical and molecular charactensation made in the present study was based on distinct variants from each taxa This needs to be further strengthened by subjecting all the accessions to biochemical and molecular characterization to get a much clearer picture about the taxonomic relationships existing in *Vigna* taxa

Summary

6 SUMMARY

The study entitled Characterisation and systematic evaluation of genetic resources of the genus *Vigna* was carried out in the Department of Plant Breeding and Genetics College of Horticulture at Vellanikkara during the period 2005 2008 The objectives of the study were to characterise the available accessions of *Vigna* germplasm at National Bureau of Plant Genetic Resources (NBPGR) Regional Station Vellanikkara Thrissur using morphological markers and to confirm the results using biochemical and molecular markers in distinct variants in different taxa as well as to prepare a key for the identification of different *Vigna* taxa

Morphological characterisation of 150 accessions of *Vigna* was based on 48 qualitative and 24 quantitative characters The biochemical characterisation of the distinct variants from each taxa was done using isozymes peroxidase and poly phenol oxidase Inter Sequence Repeat Analysis using 10 different primers was done for molecular characterisation The clustering patterns obtained with qualitative quantitative biochemical and molecular characters were compared and a key for identification of different taxa of *Vigna* was prepared

Based on the qualitative characters the 150 accession of *Vigna* were regrouped into 22 different taxa which included a new *Vigna* species which did not fit into any of the known taxa

Among the qualitative characters considered for morphological characterisation type of seed germination nature of attachment of primary leaves size and shape of stipules presence of ligule shape of bracteole nature of pod attachment to peduncle curvature of pod shape of seed and shape of hilum were distinct for each taxa

The accession varied in the type of germination and nature of attachment of primary leaves The germination was epigeal and primary leaf attachment was petiolate in *V t lobata V g c la a* and the new *V g a* species It was epigeal and sub sessıle ın *V khandalensıs V mungo* var *mungo V mungo* var *sylvestrıs V radıata* var *radıata V radıata* var *setulosa V radıata* var *sublobata V haınıana* and *V subramanıana* In *V aconıtıfolıa V dalzellıana V marına V pılosa V stıpulacea V glabrescens V trınervıa* var *bourneae V trınervıa* var *trınervıa V umbellata* var *umbellata* and *V umbellata* var *gracılıs* ıt was hypogeal and petıolate Hypogeal germınatıon and sub sess le attachment of prımary leaf was observed ın *V vexıllata*

Ornamentatıon was present on the leaves of *V stıpulacea V trınervıa* var *bourneae* and *V dalzellıana* but was absent n all the other taxa The colour of ornamentatıon was eıther whıte as ın *V stıpulacea* and *V trınervıa* var *bourneae* or green as ın *I dalzellıana*

The taxa evaluated varıed ın sıze and shape of stıpules The shape of stıpule was lanceolate n *V aconıtıfolıa V dalzellıana V marına V mungo* var *mungo V n ı ngo* var *sylvestrıs* and *V pılosa* ovate lanceolate ın *V trınerv a* var *boı ıneae V tr nerv a* var *trınerv a V ı mbellata* var *umbellata V umbellata* var *gracılıs V ı ngı ıculata* and *V vexıllata* ovate ın *V haın ana V kha ıdalens s V radıata* var *radıata V radıata* var *sı blobata V radıata* var *set ılosa V st p ılacea V subraman ana V tr lobata*

All the 24 quant tatıve characters studıed exhıbıted wıde range of varıabılıty Varıab lıty of more than 90 percent was observed ın characters lıke seed yıeld/plant number of lobes n term nal leaflet 100 seed weıght and sıze of flower bud The characters whıch showed varıab l y of less than 30 percent were wıdth of termınal leaflet length of termınal pet olule number of pods/peduncle number of prımary branches seed wıdth and number of seeds/pod

The keel pocket was present ın all taxa except n *V ngu c lata V marına* and *V p losa* The length of keel pocket varıed from taxa to taxa The keel pocket was long ın *V ngo* var *syl est s* and *V bella a* var *bellata* m nute

V haımıana V trılobata and *V stıpulacea* and short or medıum short ın all the other taxa

The 150 accessıons evaluated could be grouped ınto 10 clusters based on qualıtatıve characters at 60 percent sımılarıty level Clusterıng pattern revealed that all accessıons belongıng to sıngle taxa grouped together ın the same cluster

Cluster analysıs performed usıng all quantıtatıve characters resulted ın five clusters The maxımum dıstance was observed between cluster I and IV and the mınımum between cluster I and II

The accessıons varıed ın theır susceptıb lıty to storage pest ınfestatıon The ınfestatıon ranged from 0 100 percent No ınfestatıon was observed ın 55 accessıons belongıng to dıfferent taxa except *V aconıtıfolıa V subramanıana* and the new specıes Hundred percent ınfestatıon was observed ın two accessıons one each n *V umbellata* var *umbellata* and *V ungı ıculata*

Palynologıcal study of the accessıons revealed that the pollen graıns of all *Vıgna* taxa were monods trızonoporate obtuse and convex Max mum varıabılıty was observed ın thıckness of exıne The exıne was thın ın *V haın ana V trolobata* and *V stıpulacea* and thıck ın *V vex llata V ung ıc ılata* and *V p losa* Pollen gra ns were large ın *V vexıllata* and *V ı ngı ıcı lata* and small ın *V haı ıana V t ılobata* and *V stıpı lacea* The shape of pollen was e ther c rcular or trıangular *V radıata* var *rad ata V radıata* var *set losa V t nervıa* var *bourneae V trınervıa* var *trınervıa V nguıculata* and *V vexıllata* were hav ng trıangular pollen gra ns The sculpturıng was nıcro retıculate ın all taxa except *V glabrescens* and *V vex llata* In *V glab escens* tl e sculpturıng was retıculate and n *V vexıllata* ıt was scabrate The sp nes on the ex ne were m nute ın all taxa except ın *V vex llata* and *V ı g culata* In *V vex llata* and *V ung c ılata* the sp nes were ech nate Psılate sp nes were found n *V p losa* and *V st p lacea*

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Based on ısozyme analysıs usıng perox dase (POX) and poly phenol oxıdase (POP) enzymes the selected accessıons could be grouped ınto 4 clusters at 75 percent sımılanty

All the 10 pnmers used n the ISSR analys s of the selected accessıons produced unambıguous markers Ten ISSR pnmers produced a total of 153 markers across 33 genotypes and all were polymorphıc Among the pnmers used the pnmer UBC 842 produced the hıghest number of fragments whıle the pnmers UBC 813 and UBC 856 produced the lowest number of fragments The 33 accessıons formed 12 clusters at 70 percent sımılanty level

The homology among the clustenng patterns obta ned usıng qual tatıve quant tatıve bıochemıcal and molecular characters was studıed based on percent dıstnbutıon of the accessıons belongıng to each of the qualıtat ve clusters ınto vanous quant tatıve bıochemıcal and molecular clusters The results showed that there exısted a sımılanty between clusters formed based on qual tatıve and quantıtatıve characters wıth majonty of access ons of each taxa n a qualıtatıve cluster fallıng ın the same quantıtatıve cluster Key quantıtatıve characters for 22 dıfferent taxa of *Vigna* were ıdent fied based on the quantum of vanabılıty and weıghted averages of vanous quant tatıve characters

The accessıons taken for ısozyme and molecular study were dıstınct vanants hence fell ın dıfferent clusters formed based on the respectıve markers When the dıstnbutıon of selected access ons ın the clusters formed based on ısozyme molecular and quant tat ve characters were compared t was seen that accessıons of same taxa whıch fell ın same clusters based on ısozyme and molecular markers fell ın dıfferent clusters based on quant tatıve characters and v ce versa ındıcatıng the extend of sımılanty at vanous levels It was also seen that the selected access ons belong ng to a s ngle taxa fell ın s gle cluster based on sozyme markers but ın t vo or three d fferent clusters based on molecular markers The accessions that fell in same cluster based on isozyme and molecular markers fell in different clusters formed based on quantitative characters

Based on the morphological biochemical and molecular characters a dichotomous key for identification of *Vigna* species was developed In the key after the morphological characters biochemical and molecular characters for each species was indicated as numerals which represent the number of bands obtained Unlike the earlier keys where only floral and fruit characters were considered the present key proposed was developed taking into consideration all the characters starting from germination to fru t and seed characters

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				1	2	3	4	5	6	7	8	9	10
Sl No	TCR No	Code for taxa	Taxa	Days to emergence	Type of seed germination	Colour of hypocotyl	Vigour of seedling	Shape of primary leaf	Primary leaf length (cm)	Primary leaf width (cm)	Colour of primary leaf petiole	Nature of attachment of primary leaf	Habit
87	259	Vms9	*V mungo* var *sylvestris*	6	1	1	3	2	3 43	1 53	1	2	1
88	260	Vms10	*V mungo* var *sylvestris*	7	1	1	3	2	2 77	1 23	1	2	1
89	262	Vms11	*V mungo* var *sylvestris*	7	1	1	3	2	3 17	1 70	1	2	1
90	265	Vms12	*V mungo* var *sylvestris*	6	1	1	3	2	3 77	1 57	1	2	1
91	266	Vms13	*V mungo* var *sylvestris*	6	1	1	3	2	3 37	1 50	1	2	1
92	267	Vms14	*V mungo* var *sylvestris*	6	1	1	3	2	3 23	1 60	1	2	1
93	268	V	New *Vigna* species	11	1	1	2	2	2 17	1 10	1	1	1
94	270	Vms15	*V mungo* var *sylvestris*	7	1	1	3	2	3 07	1 57	1	2	1
95	271	Vms16	*V mungo* var *sylvestris*	6	1	1	3	2	3 47	1 17	1	2	1
96	272	Vms17	*V mungo* var *sylvestris*	6	1	1	3	2	3 60	1 70	1	2	1
97	273	Vse6	*V radiata* var *setulosa*	7	1	1	2	2	2 87	1 33	1	2	1
98	274	Vd16	*V dalzelliana*	8	2	1	2	2	1 50	1 23	2	1	1
99	275	Vms18	*V mungo* var *sylvestris*	6	1	1	3	2	3 30	1 53	1	2	1
100	276	Vms19	*V mungo* var *sylvestris*	6	1	1	3	2	3 13	1 53	1	2	1
101	277	Vtb11	*V trinervia* var *bourneae*	7	2	4	3	1	2 23	1 77	2	1	1
102	278	Vrs7	*V radiata* var *sublobata*	8	1	2	2	2	1 93	1 23	2	2	1
103	279	Vrs8	*V radiata* var *sublobata*	8	1	2	2	2	1 87	1 27	2	2	1
104	284	Vun2	*Vigna unguiculata*	2	1	1	4	1	6 73	3 90	1	1	1
105	290	Vtb12	*V trinervia* var *bourneae*	8	2	2	2	1	2 00	1 63	2	1	1
106	295	Vt6	*V trilobata*	8	2	2	2	5	1 20	1 07	1	1	1
107	297	Vrs9	*V radiata* var *sublobata*	11	1	2	1	2	1 50	1 00	2	2	1
108	298	Vu11	*Vigna umbellata* var *umbellata*	8	2	4	3	3	3 60	1 03	3	1	1
109	300	Vrs10	*V radiata* var *sublobata*	11	1	1	2	2	1 77	1 07	1	2	1
110	301	Vrs11	*V radiata* var *sublobata*	6	1	4	3	2	2 83	1 60	2	2	1
			[illegible]	11	2	1	2	1	1 [illegible]	1 30	1	1	1

				1	2	3	4	5	6	7	8	9	10
Sl No	TCR No	Code for taxa	Taxa	Days to emergence	Type of seed germination	Colour of hypocotyl	Vigour of seedling	Shape of primary leaf	Primary leaf length (cm)	Primary leaf width (cm)	Colour of primary leaf petiole	Nature of attachment of primary leaf	Habit
112	303	Vst3	*V stipulaceae*	8	1	2	1	5	0 90	0 73	1	1	1
113	305	Vt7	*V trilobata*	8	2	2	1	5	1 27	1 20	1	1	1
114	306	Vt8	*V trilobata*	8	2	2	2	5	1 53	1 33	1	1	1
115	307	Vh8	*V hainiana*	7	2	1	2	2	2 73	1 17	1	2	1
116	308	Vun3	*Vigna unguiculata*	3	1	1	4	1	3 80	2 47	1	1	1
117	310	Vmu1	*V mungo* var *mungo*	3	1	4	3	2	5 30	0 93	2	2	1
118	311	Vtb13	*V trinervia* var *bourneae*	8	2	2	2	1	1 97	1 47	1	1	1
119	313	Vmu2	*V mungo* var *mungo*	3	1	4	2	2	4 43	1 67	2	2	1
120	314	Vh9	*V hainiana*	6	2	1	2	2	2 00	1 03	1	2	1
121	318	Vt9	*V trilobata*	8	2	2	2	5	1 40	1 17	1	1	1
122	319	Vt10	*V trilobata*	8	2	2	2	5	1 13	1 07	1	1	1
123	320	Vt11	*V trilobata*	8	2	2	2	5	1 20	1 03	1	1	1
124	321	Vrs12	*V radiata* var *sublobata*	8	1	2	2	2	1 43	1 07	1	2	1
125	323	Vh10	*V hainiana*	11	2	3	1	2	1 60	0 75	1	2	1
126	330	Vug2	*V umbellata* var *gracilis*	11	2	4	2	4	1 57	1 30	3	1	1
127	331	Vug3	*V umbellata* var *gracilis*	11	2	4	2	4	1 17	0 97	3	1	1
128	334	Vug4	*V umbellata* var *gracilis*	11	2	4	2	4	1 47	1 00	3	1	1
129	342	Vtb14	*V trinervia* var *bourneae*	11	2	4	3	1	2 00	1 53	3	1	1
130	345	Vtb15	*V trinervia* var *bourneae*	6	2	4	2	1	2 40	1 90	2	1	1
131	348	Vtb16	*V trinervia* var *bourneae*	6	2	4	2	1	1 97	1 47	2	1	1
132	350	Va	*V aconitifolia*	3	2	1	1	3	3 30	1 00	1	1	1
133	384	Vtb17	*V trinervia* var *bourneae*	8	2	4	2	1	1 90	1 73	2	1	1
134	385	Vtb18	*V trinervia* var *bourneae*	11	2	4	2	1	1 45	1 10	2	1	1
135	387	Vd17	*V dalzelliana*	13	2	4	2	4	1 43	1 17	3	1	1

			24	25	26	27	28	29	30	31	32	33	34	35
Sl No	TCR No	Code for taxa	No of lobes in terminal leaflet	Terminal leaflet length (cm)	Terminal leaflet width (cm)	Shape of terminal leaflet tip	Shape of terminal leaflet lobe	Petiole length (cm)	Size of stipule	Shape of stipule	Presence of ligule	Twining tendency	No of primary branches	Branching pattern of primary branches
1	1	Vrs1	3	6 73	6 00	2	2	6 33	2	1	2	4	4	4
2	2	Vst1	3	4 40	4 07	5	4	4 27	1	1	2	4	3	4
3	3	Vrs2	3	6 50	5 60	2	2	10 50	2	1	2	4	4	4
4	5	Vrs3	3	6 00	5 53	2	2	6 50	2	1	2	4	4	4
5	7	Vrs4	3	6 33	5 90	2	2	7 77	2	1	2	4	4	4
6	8	Vtb1	3	9 83	8 33	4	3	10 83	2	2	2	4	3	4
7	9	Vd1	3	11 13	10 00	4	5	14 00	4	3	2	4	3	4
8	10	Vd2	3	8 10	6 10	4	5	14 67	4	3	2	4	3	4
9	11	Vrs5	3	6 33	6 03	2	2	6 50	2	1	2	4	4	4
10	12	Vd3	3	7 43	5 23	4	5	10 97	4	3	2	4	3	4
11	13	Vd4	3	7 90	5 73	4	5	10 83	4	3	2	4	3	4
12	18	Vug1	0	7 17	4 10	4	0	6 33	1	2	2	4	3	4
13	20	Vg	0	14 83	11 47	4	0	26 33	3	1	2	1	6	4
14	24	Vh1	0	7 20	5 50	4	0	4 50	2	1	2	4	3	2
15	26	Vh2	0	12 00	2 60	4	0	5 00	2	1	2	4	3	2
16	29	Vh3	0	8 50	7 20	4	0	14 00	2	1	2	4	3	2
17	60	Vr1	3	9 43	6 67	2	4	9 67	2	1	2	1	2	3
18	61	Vr2	3	7 83	6 47	2	4	7 90	2	1	2	4	2	4
19	62	Vr3	3	10 17	9 07	2	4	12 43	2	1	2	1	3	4
20	66	Vrs6	0	6 50	5 97	2	0	6 67	2	1	2	4	4	4

				1	2	3	4	5	6	7	8	9	10
Sl No	TCR No	Code for taxa	Taxa	Days to emergence	Type of seed germination	Colour of hypocotyl	Vigour of seedling	Shape of primary leaf	Primary leaf length (cm)	Primary leaf width (cm)	Colour of primary leaf petiole	Nature of attachment of primary leaf	Habit
136	388	Vd18	*V dalzelliana*	11	2	4	2	4	1 15	0 95	3	1	1
137	390	Vms20	*V mungo* var *sylvestris*	8	1	1	2	2	2 40	1 15	1	2	1
138	392	Vms21	*V mungo* var *sylvestris*	8	1	1	2	2	2 50	1 57	1	2	1
139	393	Vms22	*V mungo* var *sylvestris*	14	1	1	2	2	2 05	0 80	1	2	1
140	397	Vrs13	*V radiata* var *sublobata*	11	1	1	1	2	1 00	0 60	1	2	1
141	398	Vd19	*V dalzelliana*	11	2	1	2	4	1 33	1 17	3	1	1
142	399	Vtb19	*V trinervia* var *bourneae*	11	2	4	2	1	1 90	1 53	3	1	1
143	400	Vrs14	*V radiata* var *sublobata*	10	1	1	1	2	1 87	1 03	1	2	1
144	401	Vd20	*V dalzelliana*	11	2	3	2	4	1 70	1 37	2	1	1
145	402	Vt12	*V trilobata*	8	2	2	2	5	1 33	1 23	2	1	1
146	403	Vt13	*V trilobata*	11	2	2	1	5	1 20	0 90	2	1	1
147	405	Vma	*V marina*	11	2	1	2	2	2 70	1 60	1	1	1
148	407	Vd21	*V dalzelliana*	8	2	2	3	4	1 93	1 67	1	1	1
149	410	Vp	*V pilosa*	8	2	1	2	6	3 15	2 65	1	1	1
150	161 A	Vrs15	*V radiata* var *sublobata*	7	1	2	2	2	2 13	1 17	2	2	1

			11	12	13	14	15	16	17	18	19	20	21	22	23
Sl No	TCR No	Code for taxa	Growth habit	Growth pattern	Leafiness	Pubescense of leaf	Colour of petiole	Colour of petiole at leaf blade joint	Colour of petiole at base	Pubescence of petiole	Colour of petiolule	Terminal petiolule length (cm)	Prominence of leaf vein	Pigmentation of leaf vein	Lobing of terminal leaflet
1	1	Vrs1	4	2	3	2	3	3	1	2	2	1 00	1	0	2
2	2	Vst1	4	1	2	4	3	1	1	3	2	1 00	0	0	4
3	3	Vrs2	4	2	3	2	3	3	1	2	2	2 00	1	0	2
4	5	Vrs3	4	2	3	2	3	3	1	2	2	1 00	1	0	2
5	7	Vrs4	4	2	3	2	3	3	1	2	2	1 00	1	0	2
6	8	Vtb1	4	2	3	2	3	3	1	2	2	2 00	1	0	2
7	9	Vd1	4	1	3	2	1	1	1	2	1	2 00	0	0	1
8	10	Vd2	4	1	3	2	1	1	1	2	1	2 00	0	0	1
9	11	Vrs5	4	2	3	2	3	3	1	2	2	1 00	1	0	2
10	12	Vd3	4	1	3	2	1	1	1	2	1	1 00	0	0	1
11	13	Vd4	4	1	3	2	1	1	1	2	1	2 00	0	0	1
12	18	Vug1	4	2	2	2	1	1	1	1	1	1 00	0	0	0
13	20	Vg	1	1	3	1	1	1	1	1	2	2 00	0	0	0
14	24	Vh1	4	2	1	4	2	3	1	3	2	1 00	1	1	0
15	26	Vh2	4	2	1	4	2	3	1	3	2	1 00	1	1	0
16	29	Vh3	4	2	1	4	2	3	1	3	2	2 00	1	1	0
17	60	Vr1	1	1	1	2	4	3	1	3	3	2 00	1	1	3
18	61	Vr2	4	1	1	2	3	3	1	3	2	2 00	1	1	3
19	62	Vr3	1	1	2	2	3	3	1	3	3	3 00	1	1	3
0	66	Vrs6	4	2	2	2	3	3	3	3	3	1 00	1	1	0

			11	12	13	14	15	16	17	18	19	20	21	22	23
Sl No	TCR No	Code for taxa	Growth habit	Growth pattern	Leafiness	Pubescence of leaf	Colour of petiole	Colour of petiole at leaf blade joint	Colour of petiole at base	Pubescence of petiole	Colour of petiolule	Terminal petiolule length (cm)	Prominence of leaf vein	Pigmentation of leaf vein	Lobing of terminal leaflet
21	67	Vse1	4	2	2	2	3	3	3	3	3	2 00	1	1	0
22	68	Vse2	4	2	2	2	3	3	3	3	3	1 00	1	1	0
23	69	Vse3	4	2	2	2	3	3	3	3	3	2 00	1	1	0
24	70	Vr4	1	1	1	2	3	3	1	3	2	2 00	1	1	3
25	71	Vse4	2	2	2	2	2	3	1	3	2	2 00	1	1	0
26	72	Vr5	1	1	1	4	4	3	3	3	2	2 00	1	1	0
27	74	Vr6	1	1	1	4	4	1	3	3	2	2 00	1	1	0
28	83	Vt1	4	2	2	1	1	1	1	1	1	1 00	0	0	3
29	84	Vt2	4	2	2	1	1	1	1	1	1	1 00	0	0	3
30	86	Vt3	4	2	2	1	1	1	1	1	1	1 00	0	0	3
31	87	Vu1	4	2	3	4	1	1	1	2	1	2 00	1	0	2
32	88	Vu2	4	2	3	4	1	1	1	2	1	2 00	1	0	2
33	89	Vu3	4	2	3	4	1	1	1	2	1	3 00	1	0	2
34	90	Vu4	4	2	3	4	1	1	1	2	1	3 00	1	0	2
35	91	Vu5	4	2	3	4	1	1	1	2	1	2 00	1	0	2
36	92	Vu6	4	2	3	4	1	1	1	2	1	2 00	1	0	2
37	93	Vu7	4	2	3	4	1	1	1	2	1	3 00	1	0	2
38	94	Vu8	4	2	3	4	1	1	1	2	1	2 00	1	0	2
39	95	Vu9	4	2	3	4	1	1	1	2	1	3 00	1	0	2
40	106	Vd5	4	1	3	2	1	1	1	2	1	1 00	0	0	1
41	121	Vtb2	4	2	3	2	3	3	1	2	2	2 00	1	0	2
42	126	Vd6	4	1	3	2	1	1	1	2	1	1 00	0	0	1
43	141	Vse5	4	2	3	2	3	3	1	2	2	1 00	1	0	0
44	42	Vtb3	4	2	3	2	3	3	1	2	2	2 00	1	0	2

			11	12	13	14	15	16	17	18	19	20	21	22	23
Sl No	TCR No	Code for taxa	Growth habit	Growth pattern	Leafiness	Pubescense of leaf	Colour of petiole	Colour of petiole at leaf blade joint	Colour of petiole at base	Pubescence of petiole	Colour of petiolule	Terminal petiolule length (cm)	Prominence of leaf vein	Pigmentation of leaf vein	Lobing of terminal leaflet
45	143	Vd7	4	1	3	2	1	1	1	2	1	1 00	0	0	1
46	144	Vd8	4	1	3	2	1	1	1	2	1	1 00	0	0	1
47	147	Vd9	4	2	3	2	1	1	1	2	1	1 00	0	0	1
48	155	Vms1	4	2	3	5	2	3	3	3	2	1 00	1	0	0
49	156	Vtb4	4	2	3	2	3	3	1	2	2	2 00	1	0	2
50	157	Vms2	4	2	3	5	2	3	3	3	2	2 00	1	0	0
51	158	Vms3	4	2	3	5	2	3	3	3	2	2 00	1	0	0
52	160	Vms4	4	2	3	5	2	3	3	3	2	2 00	1	0	0
53	161	Vv1	4	2	2	1	1	1	1	1	3	1 00	0	0	0
54	162	Vv2	4	2	2	1	1	1	1	1	3	1 00	0	0	0
55	163	Vd10	4	2	3	2	1	1	1	2	1	1 00	0	0	1
56	164	Vtb5	4	2	3	2	3	3	1	2	2	1 00	1	0	2
57	165	Vk	1	1	3	5	1	1	1	1	1	1 70	1	0	2
58	169	Vv3	4	2	2	1	1	1	1	1	3	1 00	0	0	0
59	171	Vms5	4	2	3	5	2	3	3	3	2	1 00	1	0	0
60	174	Vtb6	4	2	3	2	3	3	1	2	2	1 00	1	0	2
61	176	Vtb7	4	1	3	2	1	1	1	2	1	2 00	0	0	0
62	188	Vr7	4	2	3	2	3	3	1	2	2	1 00	1	0	0
63	189	Vtb8	4	2	3	2	3	3	1	2	2	2 00	1	0	2
64	192	Vt4	4	2	2	1	1	1	1	1	1	1 00	0	0	3
65	195	Vtb9	4	2	3	2	3	3	1	2	2	1 00	1	0	2

			11	12	13	14	15	16	17	18	19	20	21	22	23
Sl No	TCR No	Code for taxa	Growth habit	Growth pattern	Leafiness	Pubescense of leaf	Colour of petiole	Colour of petiole at leaf blade joint	Colour of petiole at base	Pubescence of petiole	Colour of petiolule	Terminal petiolule length (cm)	Prominence of leaf vein	Pigmentation of leaf vein	Lobing of terminal leaflet
66	199	Vd11	4	1	3	2	1	1	1	2	1	2 00	0	0	1
67	204	Vu10	4	2	3	4	1	1	1	2	1	3 00	1	0	2
68	206	Vtb10	4	2	3	2	3	3	1	2	2	1 00	1	0	2
69	207	Vh4	4	2	1	4	2	3	1	3	2	1 00	1	1	0
70	208	Vun1	4	2	3	1	1	3	1	1	1	2 00	0	0	0
71	214	Vd12	4	1	3	2	1	1	1	2	1	1 00	0	0	1
72	215	Vst2	4	2	3	4	1	1	1	3	2	1 00	1	0	3
73	217	Vv4	4	2	2	1	1	1	1	1	3	1 00	0	0	0
74	230	Vms6	4	2	3	5	2	3	3	3	2	1 00	1	0	0
75	233	Vd13	4	2	3	2	1	1	1	2	1	1 00	1	0	0
76	234	Vd14	4	2	3	2	1	1	1	2	1	1 00	1	0	0
77	238	Vsb1	4	2	2	2	3	3	3	3	3	1 00	1	1	0
78	240	Vsb2	4	2	2	2	3	3	3	3	3	2 00	1	1	0
79	241	Vsb3	4	2	2	2	3	3	3	3	3	1 00	1	1	0
80	243	Vt5	4	2	3	1	1	1	1	1	1	1 00	0	0	4
81	244	Vh5	4	2	1	4	2	3	1	3	2	1 00	1	1	0
82	247	Vh6	4	2	2	5	3	2	1	4	2	2 00	1	1	0
83	249	Vh7	4	2	1	4	2	3	1	3	2	2 00	1	1	0
84	254	Vms7	4	2	3	5	2	3	3	3	2	1 00	1	0	0
85	256	Vms8	4	2	3	5	2	3	3	2	2	1 00	1	0	0
86	258	Vd15	4	2	3	2	1	1	1	2	1	1 00	0	0	1

			11	12	13	14	15	16	17	18	19	20	21	22	23
Sl No	TCR No	Code for taxa	Growth habit	Growth pattern	Leafiness	Pubescense of leaf	Colour of petiole	Colour of petiole at leaf blade joint	Colour of petiole at base	Pubescence of petiole	Colour of petiolule	Terminal petiolule length (cm)	Prominence of leaf vein	Pigmentation of leaf vein	Lobing of terminal leaflet
87	259	Vms9	4	2	3	5	2	3	3	3	2	1 00	1	0	0
88	260	Vms10	4	2	3	5	2	3	3	3	2	1 00	1	0	0
89	262	Vms11	4	2	3	5	2	3	3	3	2	1 00	1	0	0
90	265	Vms12	4	2	3	5	2	3	3	3	2	1 00	1	0	0
91	266	Vms13	4	2	3	5	2	3	3	3	2	1 00	1	0	0
92	267	Vms14	4	2	3	5	2	3	3	3	2	2 00	1	0	0
93	268	V	4	2	3	1	3	3	4	1	2	1 00	1	0	0
94	270	Vms15	4	2	3	5	2	3	3	2	2	1 00	1	0	0
95	271	Vms16	4	2	3	5	2	3	3	3	2	1 00	1	0	0
96	272	Vms17	4	2	3	5	2	3	3	3	2	2 00	1	0	0
97	273	Vse6	4	2	2	2	3	3	3	3	3	1 00	1	1	0
98	274	Vd16	4	2	1	4	2	3	1	3	2	1 00	1	1	0
99	275	Vms18	4	2	3	5	2	3	3	3	2	1 00	1	0	0
100	276	Vms19	4	2	3	5	2	3	3	3	2	1 00	1	0	0
101	277	Vtb11	4	2	3	2	3	3	1	2	2	2 00	1	0	2
102	278	Vrs7	4	2	3	2	3	3	1	2	2	2 00	1	0	2
103	279	Vrs8	4	2	3	2	3	3	1	2	2	1 00	1	0	2
104	284	Vun2	4	2	3	1	1	3	1	1	1	3 00	0	0	0
105	290	Vtb12	4	2	3	2	3	3	1	2	2	1 00	1	0	2
106	295	Vt6	4	2	3	1	1	1	1	1	1	1 00	0	0	4
107	297	Vrs9	4	2	3	2	3	3	1	2	2	1 00	1	0	0
108	298	Vu11	4	2	3	4	1	1	1	2	1	2 00	1	0	2
109	300	Vrs10	4	2	3	2	3	3	1	2	2	1 00	1	0	0
110	301	Vrs11	4	2	3	2	3	3	1	2	2	2 00	1	0	0
	[illegible]	[illegible]	4	1	3	4	2	3	1	4	2	1 00	0	0	2

			11	12	13	14	15	16	17	18	19	20	21	22	23
Sl No	TCR No	Code for taxa	Growth habit	Growth pattern	Leafiness	Pubescense of leaf	Colour of petiole	Colour of petiole at leaf blade joint	Colour of petiole at base	Pubescence of petiole	Colour of petiolule	Terminal petiolule length (cm)	Prominence of leaf vein	Pigmentation of leaf vein	Lobing of terminal leaflet
112	303	Vst3	4	2	2	1	1	1	1	1	1	1 00	0	0	3
113	305	Vt7	4	2	2	1	1	1	1	1	1	1 00	0	0	3
114	306	Vt8	4	2	2	1	1	1	1	1	1	1 00	0	0	3
115	307	Vh8	4	2	2	5	3	2	1	4	2	1 00	1	1	0
116	308	Vun3	4	2	3	1	1	3	1	1	1	3 00	0	0	0
117	310	Vmu1	1	1	1	4	3	2	1	3	2	2 00	0	0	0
118	311	Vtb13	4	2	3	2	3	3	1	2	2	1 00	1	0	2
119	313	Vmu2	1	1	1	4	3	2	1	3	2	2 00	0	0	0
120	314	Vh9	4	2	2	5	3	2	1	4	2	1 00	1	1	0
121	318	Vt9	4	2	2	1	1	1	1	1	1	1 00	0	0	3
122	319	Vt10	4	2	2	1	1	1	1	1	1	1 00	0	0	3
123	320	Vt11	4	2	2	1	1	1	1	1	1	1 00	0	0	3
124	321	Vrs12	4	2	3	2	3	3	1	2	2	2 00	1	0	2
125	323	Vh10	4	2	1	2	1	1	1	2	2	1 00	1	0	0
126	330	Vug2	4	2	2	2	1	1	1	1	1	1 00	0	0	0
127	331	Vug3	4	2	2	2	1	1	1	1	1	1 00	0	0	0
128	334	Vug4	4	2	2	2	1	1	1	1	1	1 00	0	0	0
129	342	Vtb14	4	2	3	2	3	3	1	2	2	2 00	1	0	2
130	345	Vtb15	4	2	3	2	3	3	1	2	2	1 00	1	0	2
131	348	Vtb16	4	2	3	2	3	3	1	2	2	1 00	1	0	2
132	350	Va	3	2	2	4	1	1	1	3	1	1 00	0	0	5
133	384	Vtb17	4	2	3	2	3	3	1	2	2	2 00	1	0	2
134	385	Vtb18	4	2	3	2	3	3	1	2	2	1 00	1	0	2
135	387	Vd17	4	1	3	2	1	1	1	2	1	2 00	0	0	1

			11	12	13	14	15	16	17	18	19	20	21	22	23
Sl No	TCR No	Code for taxa	Growth habit	Growth pattern	Leafiness	Pubescense of leaf	Colour of petiole	Colour of petiole at leaf blade joint	Colour of petiole at base	Pubescence of petiole	Colour of petiolule	Terminal petiolule length (cm)	Prominence of leaf vein	Pigmentation of leaf vein	Lobing of terminal leaflet
136	388	Vd18	4	2	3	2	1	1	1	2	1	2 00	0	0	1
137	390	Vms20	4	2	3	5	2	3	3	3	2	1 00	1	0	0
138	392	Vms21	4	2	3	5	2	3	3	3	2	1 00	1	0	0
139	393	Vms22	4	2	3	5	2	3	3	3	2	1 00	1	0	0
140	397	Vrs13	4	2	3	2	3	3	1	2	2	1 00	1	0	0
141	398	Vd19	4	1	3	2	1	1	1	2	1	1 00	0	0	1
142	399	Vtb19	4	2	3	2	3	3	1	2	2	1 00	1	0	2
143	400	Vrs14	4	2	3	2	3	3	1	2	2	1 00	1	0	0
144	401	Vd20	4	2	3	2	1	1	1	2	1	1 00	0	0	1
145	402	Vt12	2	2	1	1	1	1	1	1	1	1 00	0	0	3
146	403	Vt13	4	2	2	1	1	1	1	1	1	1 00	0	0	3
147	405	Vma	4	2	3	1	1	1	1	1	1	2 00	1	0	0
148	407	Vd21	4	1	3	2	1	1	1	2	1	1 00	0	0	0
149	410	Vp	4	2	2	4	1	1	1	3	1	1 00	1	0	0
150	161 A	Vrs15	4	2	2	2	3	3	3	3	3	1 00	1	1	0

			24	25	26	27	28	29	30	31	32	33	34	35
Sl No	TCR No	Code for taxa	No of lobes in terminal leaflet	Terminal leaflet length (cm)	Terminal leaflet width (cm)	Shape of terminal leaflet tip	Shape of terminal leaflet lobe	Petiole length (cm)	Size of stipule	Shape of stipule	Presence of ligule	Twining tendency	No of primary branches	Branching pattern of primary branches
21	67	Vse1	0	7 83	7 76	2	0	8 07	2	1	2	4	4	4
22	68	Vse2	0	8 93	7 57	2	0	7 67	2	1	2	4	4	4
23	69	Vse3	0	10 17	9 70	2	0	10 00	2	1	2	4	4	4
24	70	Vr4	3	12 30	9 20	2	6	11 00	2	1	2	1	3	4
25	71	Vse4	0	8 70	7 77	3	0	7 47	2	1	2	2	3	4
26	72	Vr5	0	10 30	8 23	2	0	11 77	2	1	2	1	3	4
27	74	Vr6	0	11 20	8 83	2	0	9 10	2	1	2	1	3	4
28	83	Vt1	3	3 90	4 07	1	4	5 73	3	1	2	4	3	4
29	84	Vt2	3	4 80	4 50	1	4	9 00	3	1	2	4	3	4
30	86	Vt3	3	4 10	3 70	1	4	5 37	3	1	2	4	3	4
31	87	Vu1	3	11 50	6 33	4	1	12 67	4	2	2	4	2	4
32	88	Vu2	3	13 30	7 83	4	1	17 00	4	2	2	4	2	4
33	89	Vu3	3	13 67	9 83	4	1	17 00	4	2	2	4	2	4
34	90	Vu4	3	13 50	9 50	4	1	13 67	4	2	2	4	2	4
35	91	Vu5	3	12 33	6 97	4	1	21 67	4	2	2	4	2	4
36	92	Vu6	3	10 67	6 83	4	1	21 67	4	2	2	4	2	4
37	93	Vu7	3	12 83	8 67	4	1	21 67	4	2	2	4	2	4
38	94	Vu8	3	11 17	6 67	4	1	13 67	4	2	2	4	2	4
39	95	Vu9	3	12 40	9 23	4	1	17 33	4	2	2	4	2	4
40	106	Vd5	3	7 83	6 10	4	5	11 67	4	3	2	4	3	4
41	121	Vtb2	3	10 30	7 93	4	3	13 83	2	2	2	4	3	4
42	126	Vd6	3	8 73	6 97	4	5	15 67	4	3	2	4	3	4
43	141	Vse5	0	6 37	5 60	2	0	6 20	2	1	2	4	4	4
44	142	Vth	3	8 17	6 90	4	3	7 90	2	2	2	4	3	4

			24	25	26	27	28	29	30	31	32	33	34	35
Sl No	TCR No	Code for taxa	No of lobes in terminal leaflet	Terminal leaflet length (cm)	Terminal leaflet width (cm)	Shape of terminal leaflet tip	Shape of terminal leaflet lobe	Petiole length (cm)	Size of stipule	Shape of stipule	Presence of ligule	Twining tendency	No of primary branches	Branching pattern of primary branches
45	143	Vd7	3	6 20	4 47	4	5	5 33	4	3	2	4	3	4
4(	144	Vd8	3	6 20	4 33	4	5	5 77	4	3	2	4	3	4
47	147	Vd9	3	6 83	4 67	4	5	5 83	4	3	2	4	5	4
48	155	Vms1	0	8 33	6 07	4	0	7 43	2	3	2	4	3	1
49	156	Vtb4	3	9 13	7 60	4	3	9 70	2	2	2	4	3	4
50	157	Vms2	0	9 67	6 80	4	0	9 67	2	3	2	4	2	1
51	158	Vms3	0	8 97	6 36	4	0	8 83	2	3	2	4	2	1
52	160	Vms4	0	9 37	6 67	4	0	11 00	2	3	2	4	2	1
53	161	Vv1	0	7 50	4 87	4	0	6 17	4	2	0	4	3	4
54	162	Vv2	0	7 43	5 00	4	0	7 00	4	2	0	4	3	4
55	163	Vd10	3	7 57	4 60	4	5	8 33	4	3	2	4	5	4
56	164	Vtb5	3	9 17	7 33	4	3	7 67	2	2	2	4	3	4
57	165	Vk	0	13 43	12 67	4	0		4	1	1	1	1	0
58	169	Vv3	0	6 67	3 67	4	0	4 33	4	2	0	4	3	4
59	171	Vms5	0	7 90	6 50	4	0	10 50	2	3	2	4	2	1
60	174	Vtb6	3	6 97	5 60	4	3	8 30	2	2	2	4	3	4
61	176	Vtb7	0	10 67	9 47	4	0	11 17	4	2	1	4	3	4
62	188	Vr7	0	6 97	5 33	2	0	8 17	2	1	2	4	4	4
63	189	Vtb8	3	7 70	6 67	4	3	9 17	2	2	2	4	3	4
64	192	Vt4	3	4 50	4 97	1	4	12 10	3	1	2	4	3	4
65	19>	Vtb9	3	8 07	6 90	4	3	9 77	2	2	2	4	3	4

			36	37	38	39	40	41	42	43	44	45	46	47	48
Sl No	TCR No	Code for taxa	Colour of stem	Pubescence of stem	Colour of stem hair	Days to flowering	Position of raceme	Colour of flower	Colour of calyx	Colour of corolla	Size of flower bud (l x b)	Size of bracteole	Shape of bracteole	No of flowers/raceme	Keel pocket length (mm)
87	259	Vms9	3	3	2	43	3	4	2	1	2 08	3	2	6	0 60
88	260	Vms10	3	3	2	44	3	4	2	1	2 24	3	2	6	0 50
89	262	Vms11	3	3	2	44	3	4	2	1	1 54	3	2	6	0 60
90	265	Vms12	3	3	2	48	3	4	2	1	2 10	3	2	6	0 50
91	266	Vms13	3	3	2	42	3	4	2	1	1 82	3	2	6	0 50
92	267	Vms14	3	3	2	48	3	4	2	1	1 80	3	2	6	0 60
93	268	V	1	1	0	55	3	3	2	1	1 65	2	1	8	0 30
94	270	Vms15	3	2	2	48	1	4	2	1	2 21	3	2	6	0 50
95	271	Vms16	3	3	2	49	3	4	2	1	1 65	3	2	6	0 60
96	272	Vms17	3	3	2	48	3	4	2	1	1 82	3	2	6	0 50
97	273	Vse6	2	2	1	62	1	2	2	1	1 20	3	1	9	0 25
98	274	Vd16	2	2	2	74	1	3	1	1	0 90	1	2	3	0 30
99	275	Vms18	3	3	2	49	3	4	2	1	1 43	3	2	6	0 60
100	276	Vms19	3	3	2	48	3	4	2	1	2 04	3	2	6	0 50
101	277	Vtb11	3	3	1	131	3	4	1	1	3 40	3	1	4	0 50
102	278	Vrs7	2	3	1	58	1	3	2	3	1 80	2	1	7	0 50
103	279	Vrs8	2	3	1	51	3	3	2	3	1 43	2	1	7	0 50
104	284	Vun2	2	2	2	48	3	5	1	5	5 52	0	0	4	0 00
105	290	Vtb12	3	3	1	60	3	4	1	1	1 65	3	1	4	0 20
106	295	Vt6	2	1	0	48	3	4	2	1	0 70	2	2	4	0 10
107	297	Vrs9	2	3	1	67	3	3	2	3	1 95	2	1	7	0 20
108	298	Vu11	2	3	2	87	3	4	1	1	3 57	1	2	8	0 40
109	300	Vrs10	2	3	1	61	3	3	2	3	2 08	2	1	7	0 30
110	301	Vrs11	2	3	1	53	3	3	2	3	1 56	2	1	4	0 30
11	302	Vtt	2	4	1	149	3	4	1	1	3 40	3	1	4	0 25

			24	25	26	27	28	29	30	31	32	33	34	35
Sl No	TCR No	Code for taxa	No of lobes in terminal leaflet	Terminal leaflet length (cm)	Terminal leaflet width (cm)	Shape of terminal leaflet tip	Shape of terminal leaflet lobe	Petiole length (cm)	Size of stipule	Shape of stipule	Presence of ligule	Twining tendency	No of primary branches	Branching pattern of primary branches
66	199	Vd11	3	8 00	6 43	4	5	12 17	4	3	2	4	3	4
67	204	Vu10	3	13 17	8 57	4	1	23 67	4	2	2	4	2	4
68	206	Vtb10	3	7 83	5 23	4	3	7 17	2	2	2	4	3	4
69	207	Vh4	0	6 90	5 70	4	0	5 50	2	1	2	4	3	2
70	208	Vun1	0	13 47	9 33	2	2	12 17	2	2	2	4	3	4
71	214	Vd12	3	6 63	5 20	4	5	13 17	4	3	2	4	3	4
72	215	Vst2	3	3 63	4 10	5	4	5 53	1	1	2	4	5	4
73	217	Vv4	0	7 20	3 67	4	0	7 50	4	2	0	4	3	4
74	230	Vms6	0	10 13	6 80	4	0	6 83	2	3	2	4	2	1
75	233	Vd13	0	4 67	3 60	4	0	6 33	4	3	2	4	4	4
76	234	Vd14	0	6 97	4 93	4	0	5 90	4	3	2	4	4	4
77	238	Vsb1	0	7 57	7 03	2	0	5 67	2	1	2	4	4	4
78	240	Vsb2	0	8 37	6 57	2	0	6 93	2	1	2	4	4	4
79	241	Vsb3	0	8 00	8 50	2	0	5 90	2	1	2	4	4	4
80	243	Vt5	3	3 87	3 30	5	4	5 33	3	1	2	4	5	4
81	244	Vh5	0	10 17	7 33	4	0	8 00	2	1	2	4	3	2
82	247	Vh6	0	8 50	6 73	4	0	5 67	2	1	2	4	3	4
83	249	Vh7	0	7 83	6 77	4	0	6 67	2	1	2	4	3	2
84	254	Vms7	0	10 63	7 13	4	0	11 33	2	3	2	4	2	1
85	256	Vms8	0	8 27	5 93	4	0	7 93	2	3	2	4	2	1
86	258	Vd15	3	5 70	4 40	4	5	5 07	4	3	2	4	5	4

			24	25	26	27	28	29	30	31	32	33	34	35
Sl No	TCR No	Code for taxa	No of lobes in terminal leaflet	Terminal leaflet length (cm)	Terminal leaflet width (cm)	Shape of terminal leaflet tip	Shape of terminal leaflet lobe	Petiole length (cm)	Size of stipule	Shape of stipule	Presence of ligule	Twining tendency	No of primary branches	Branching pattern of primary branches
87	259	Vms9	0	8 33	5 53	4	0	8 00	2	3	2	4	2	1
88	260	Vms10	0	9 00	4 17	4	0	9 17	2	3	2	4	2	1
89	262	Vms11	0	9 00	4 53	4	0	9 50	2	3	2	4	2	1
90	265	Vms12	0	8 23	5 57	4	0	6 50	2	3	2	4	3	1
91	266	Vms13	0	8 23	6 27	4	0	6 57	2	3	2	4	3	1
92	267	Vms14	0	8 67	6 67	4	0	7 43	2	3	2	4	3	1
93	268	V	0	8 67	2 80	4	0	6 60	2	1	2	4	4	4
94	270	Vms15	0	7 67	5 43	4	0	10 33	2	3	2	4	2	1
95	271	Vms16	0	9 53	6 53	4	0	9 50	2	3	2	4	2	1
96	272	Vms17	0	8 23	6 27	4	0	7 40	2	3	2	4	3	1
97	273	Vse6	0	7 77	7 20	2	0	6 67	3	1	2	4	4	4
98	274	Vd16	0	7 37	5 80	4	0	7 00	4	3	2	4	5	2
99	275	Vms18	0	7 70	6 50	4	0	9 43	2	3	2	4	3	1
100	276	Vms19	0	7 83	6 73	4	0	8 17	2	3	2	4	3	1
101	277	Vtb11	3	10 50	9 47	4	3	13 50	2	2	2	4	3	4
102	278	Vrs7	3	5 57	5 27	2	2	7 00	2	1	2	4	4	4
103	279	Vrs8	3	5 46	5 27	2	2	5 97	2	1	2	4	4	4
104	284	Vun2	0	11 20	7 00	2	2	13 00	2	2	2	4	3	4
105	290	Vtb12	3	7 70	5 53	4	3	11 33	2	2	2	4	3	4
106	295	Vt6	3	3 30	3 03	5	4	6 83	3	1	2	4	5	4
107	297	Vrs9	0	5 67	5 43	2	0	6 67	2	1	2	4	4	4
108	298	Vu11	3	13 67	9 83	4	1	17 00	4	2	2	4	2	4
109	300	Vrs10	0	6 57	7 03	2	0	8 17	2	1	2	4	4	4
110	301	Vrs11	0	6 50	6 13	2	0	13 67	2	1	2	4	4	4
	302	V t	3	9 40	7 90	4	5	13 33	2	2	2	4	3	4

			24	25	26	27	28	29	30	31	32	33	34	35
l No	TCR No	Code for taxa	No of lobes in terminal leaflet	Terminal leaflet length (cm)	Terminal leaflet width (cm)	Shape of terminal leaflet tip	Shape of terminal leaflet lobe	Petiole length (cm)	Size of stipule	Shape of stipule	Presence of ligule	Twining tendency	No of primary branches	Branching pattern of primary branches
12	303	Vst3	3	2 10	1 93	1	4	3 73	1	1	2	3	3	4
113	305	Vt7	3	3 47	3 20	1	4	6 40	3	1	2	3	3	4
114	306	Vt8	3	4 57	4 20	1	4	6 47	3	1	2	3	3	4
115	307	Vh8	0	7 50	6 25	4	0	7 75	2	1	2	4	3	4
116	308	Vun3	0	10 97	9 10	2	2	15 33	2	2	2	4	3	4
117	310	Vmu1	0	9 97	8 20	2	0	12 00	2	3	2	4	2	4
118	311	Vtb13	3	10 20	7 80	4	3	12 50	2	2	2	4	3	4
119	313	Vmu2	0	10 83	8 17	2	0	15 00	2	3	2	4	2	4
120	314	Vh9	0	6 00	5 03	4	1	5 83	2	1	2	4	3	4
121	318	Vt9	3	4 77	4 90	1	4	9 93	3	1	2	3	3	4
122	319	Vt10	3	3 83	3 60	1	4	5 93	3	1	2	3	3	4
123	320	Vt11	3	4 47	4 07	1	4	7 10	3	1	2	3	3	4
124	321	Vrs12	3	6 43	6 47	2	2	8 30	2	1	2	3	3	4
125	323	Vh10	0	8 50	6 50	4	0	5 00	2	1	2	4	4	4
126	330	Vug2	0	6 00	3 63	4	0	3 50	1	2	2	4	3	4
127	331	Vug3	0	5 90	4 03	4	0	4 17	1	2	2	4	3	4
128	334	Vug4	0	6 00	4 10	4	0	3 73	1	2	2	4	3	4
129	342	Vtb14	3	8 83	7 83	4	3	12 33	2	2	2	4	3	4
130	345	Vtb15	3	8 50	7 10	4	3	5 50	2	2	2	4	3	4
131	348	Vtb16	3	7 63	5 07	4	3	5 57	2	2	2	4	3	4
132	350	Va	5	5 70	5 53	4	1	6 87	4	3	2	3	4	4
133	384	Vtb17	3	10 00	8 50	4	3	13 17	2	2	2	4	3	4
134	385	Vtb18	3	7 53	6 70	4	3	9 80	2	2	2	4	3	4
135	387	Vd17	3	6 10	3 93	4	5	9 33	4	3	2	4	3	4

			24	25	26	27	28	29	30	31	32	33	34	35
Sl No	TCR No	Code for taxa	No of lobes in terminal leaflet	Terminal leaflet length (cm)	Terminal leaflet width (cm)	Shape of terminal leaflet tip	Shape of terminal leaflet lobe	Petiole length (cm)	Size of stipule	Shape of stipule	Presence of ligule	Twining tendency	No of primary branches	Branching pattern of primary branches
136	388	Vd18	3	8 47	6 20	4	5	7 17	4	3	2	4	5	4
137	390	Vms20	0	6 87	5 50	4	0	8 00	2	3	2	4	3	1
138	392	Vms21	0	7 37	5 33	4	0	12 00	2	3	2	4	3	1
139	393	Vms22	0	7 13	5 43	4	0	11 43	2	3	2	4	3	1
140	397	Vrs13	0	6 50	5 90	2	0	6 30	2	1	2	4	4	4
141	398	Vd19	3	4 37	3 87	4	5	9 17	4	3	2	4	3	4
142	399	Vtb19	3	9 57	8 37	4	3	9 83	4	2	2	4	3	4
143	400	Vrs14	0	6 07	5 50	2	0	6 00	2	1	2	4	4	4
144	401	Vd20	3	5 90	5 37	4	5	8 50	4	3	2	4	5	4
145	402	Vt12	3	5 10	5 17	3	4	8 83	3	1	2	2	3	4
146	403	Vt13	3	3 90	3 23	1	4	10 67	3	1	2	3	3	4
147	405	Vma	0	7 57	6 20	1	0	6 63	4	3	0	4	3	4
148	407	Vd21	0	7 70	5 97	4	0	9 83	4	3	1	4	3	4
149	410	Vp	0	8 47	5 30	4	0	6 43	1	3	0	4	3	4
150	161 A	Vrs15	0	10 17	9 57	2	0	16 67	3	1	2	4	4	4

			36	37	38	39	40	41	42	43	44	45	46	47	48
Sl No	TCR No	Code for taxa	Colour of stem	Pubescence of stem	Colour of stem hair	Days to flowering	Position of raceme	Colour of flower	Colour of calyx	Colour of corolla	Size of flower bud (l x b)	Size of bracteole	Shape of bracteole	No of flowers/raceme	Keel pocket length (mm)
1	1	Vrs1	2	3	1	61	1	2	2	3	1 65	2	1	7	0 25
2	2	Vst1	2	3	1	85	1	4	1	1	0 63	2	1	3	0 30
3	3	Vrs2	2	3	1	56	1	2	2	3	1 54	2	1	7	0 10
4	5	Vrs3	2	3	1	56	1	2	2	3	1 80	2	1	7	0 20
5	7	Vrs4	2	3	1	55	1	2	2	3	1 54	2	1	7	0 25
6	8	Vtb1	3	3	1	139	3	4	1	1	2 08	3	1	4	0 30
7	9	Vd1	2	2	2	131	3	4	1	1	0 90	1	2	6	0 25
8	10	Vd2	2	2	2	121	3	4	1	1	0 54	1	2	6	0 25
9	11	Vrs5	2	3	1	61	1	2	2	3	1 32	2	1	7	0 30
10	12	Vd3	2	2	2	119	3	4	1	1	0 90	1	2	6	0 25
11	13	Vd4	2	2	2	131	3	4	1	1	1 32	1	2	6	0 30
12	18	Vug1	2	1	2	69	3	3	2	1	1 80	1	1	4	0 25
13	20	Vg	3	1	0	83	2	4	1	1	2 50	1	1	8	0 25
14	24	Vh1	2	2	1	48	1	3	1	1	0 54	1	2	3	0 25
15	26	Vh2	2	2	1	75	1	3	1	1	0 45	1	2	3	0 30
16	29	Vl 3	2	2	1	55	1	3	1	1	0 40	1	2	3	0 30
17	60	Vr1	3	3	1	33	1	2	1	2	1 30	2	1	9	0 25
18	61	Vr2	3	3	1	33	2	2	1	2	1 10	2	1	5	0 30
19	62	Vr3	3	3	1	37	2	2	1	2	1 68	2	1	9	0 30
20	66	Vrs6	2	2	1	39	1	3	1	1	2 40	2	1	9	0 30

			36	37	38	39	40	41	42	43	44	45	46	47	48
Sl No	TCR No	Code for taxa	Colour of stem	Pubescence of stem	Colour of stem ha r	Days to flowering	Posit on of raceme	Colour of flower	Colour of calyx	Colour of corolla	Size of flower bud (l x b)	Size of bracteole	Shape of bracteole	No of flowers/raceme	Keel pocket length (mm)
21	67	Vse1	2	2	1	49	1	2	2	1	2 55	3	1	9	0 25
22	68	Vse2	2	2	1	51	1	2	2	1	1 30	3	1	9	0 25
23	69	Vse3	2	2	1	48	1	2	2	1	1 68	3	1	9	0 40
24	70	Vr4	1	3	1	33	2	2	2	2	1 82	2	1	5	0 40
25	71	Vse4	3	3	1	37	1	2	2	2	1 54	3	1	6	0 10
26	72	Vr5	3	3	1	39	2	2	2	2	2 72	2	1	10	0 10
27	74	Vr6	2	3	1	39	2	2	2	2	1 43	2	1	10	1 00
28	83	Vt1	1	1	0	51	3	3	2	1	0 54	2	2	5	1 00
29	84	Vt2	1	1	0	67	3	3	2	1	0 70	2	2	5	1 00
30	86	Vt3	1	1	0	55	3	3	2	1	0 70	2	2	5	1 00
31	87	Vu1	2	3	2	63	3	4	1	1	1 95	1	2	8	0 40
32	88	Vu2	2	3	2	49	3	4	1	1	2 72	1	2	8	0 50
33	89	Vu3	2	3	2	66	3	4	1	1	2 88	1	2	8	0 40
34	90	Vu4	2	3	2	70	3	4	1	1	2 47	1	2	8	0 40
35	91	Vu5	2	3	2	84	3	4	1	1	3 80	1	2	8	0 50
36	92	Vu6	2	3	2	51	3	4	1	1	2 72	1	2	8	0 50
37	93	Vu7	2	3	2	72	3	4	1	1	3 00	1	2	8	0 50
38	94	Vu8	2	3	2	45	3	4	1	1	2 55	1	2	8	0 40
39	95	Vu9	2	2	2	85	3	4	1	1	2 85	1	2	8	0 50
40	106	Vd5	2	2	2	148	3	4	1	1	1 32	1	2	5	0 25
41	121	Vtb2	3	3	1	131	3	4	1	1	3 06	3	1	4	0 30
42	126	Vd6	2	2	2	148	3	4	1	1	1 32	1	2	5	0 30
43	141	Vse5	2	3	1	51	1	4	2	4	1 76	3	1	7	0 30
44	142	Vtb3	3	3	1	83	3	4	1	1	3 00	3	1	4	0 25

			36	37	38	39	40	41	42	43	44	45	46	47	48
Sl No	TCR No	Code for taxa	Colour of stem	Pubescence of stem	Colour of sten hair	Days to flowering	Pos tion of raceme	Colour of flower	Colour of calyx	Colour of corolla	Size of flower bud (l x b)	Size of bracteole	Shape of bracteole	No of flowers/raceme	Keel pocket length (mm)
45	143	Vd7	2	2	2	126	3	3	1	1	0 63	1	2	5	0 25
46	144	Vd8	2	2	2	114	3	3	1	1	1 32	1	2	5	0 25
47	147	Vd9	2	2	2	79	3	3	1	1	0 90	1	2	5	0 30
48	155	Vms1	3	3	2	55	3	4	2	1	1 54	3	2	6	0 50
49	156	Vtb4	3	3	1	75	3	4	1	1	3 04	3	1	4	0 30
50	157	Vms2	3	3	2	60	3	4	2	1	1 95	3	2	6	0 50
51	158	Vms3	3	3	2	76	3	4	2	1	1 50	3	2	6	0 60
52	160	Vms4	3	3	2	67	3	4	2	1	1 40	3	2	6	0 50
53	161	Vv1	4	1	2	67	3	5	1	5	11 55	1	2	4	0 30
54	162	Vv2	4	1	2	68	3	5	1	5	6 60	1	2	4	0 25
55	163	Vd10	2	2	2	84	3	3	1	1	1 43	1	2	5	0 20
56	164	Vtb5	3	3	1	82	3	4	1	1	1 50	3	1	4	0 10
57	165	Vk	1	2	1	155	2	1	1	1	1 82	3	1	15	0 20
58	169	Vv3	4	1	2	75	3	5	1	5	11 55	1	2	6	0 10
59	171	Vms5	3	3	2	61	3	4	2	1	1 50	3	2	6	0 50
60	174	Vtb6	3	3	1	127	3	4	1	1	2 47	3	1	4	0 20
61	176	Vtb7	3	3	1	130	3	4	3	1	1 54	3	1	4	0 50
62	188	Vr7	2	3	1	63	1	3	2	3	1 40	2	1	7	0 50
63	189	Vtb8	3	3	1	85	3	4	3	1	2 66	3	1	4	0 50
64	192	Vt4	1	1	0	53	3	3	2	1	0 63	2	2	5	0 50
65	195	Vtb9	3	3	1	131	3	4	1	1	2 94	3	1	4	0 50

			36	37	38	39	40	41	42	43	44	45	46	47	48
Sl No	TCR No	Code for taxa	Colour of stem	Pubescence of stem	Colour of stem hair	Days to flowering	Position of raceme	Colour of flower	Colour of calyx	Colour of corolla	Size of flower bud (l x b)	Size of bracteole	Shape of bracteole	No of flowers/raceme	Keel pocket length (mm)
66	199	Vd11	2	2	2	142	3	3	1	1	1 20	1	2	5	0 50
67	204	Vu10	2	2	2	85	3	4	1	1	2 85	1	2	8	0 40
68	206	Vtb10	3	3	1	110	3	4	1	1	1 80	3	1	4	0 35
69	207	Vh4	2	2	1	48	1	3	1	1	0 42	1	2	3	0 50
70	208	Vun1	2	2	2	51	3	5	1	5	5 52	0	0	4	0 00
71	214	Vd12	2	2	2	114	3	3	1	1	1 20	1	2	5	0 50
72	215	Vst2	3	3	2	48	3	4	2	1	0 63	2	1	4	0 40
73	217	Vv4	4	1	2	71	3	5	1	5	12 58	1	2	6	0 50
74	230	Vms6	3	3	2	79	3	4	2	1	1 10	3	2	6	0 50
75	233	Vd13	2	2	2	53	3	1	1	1	0 81	1	2	3	0 50
76	234	Vd14	2	2	2	56	3	1	1	1	1 00	1	2	3	0 50
77	238	Vsb1	2	2	1	45	1	2	3	2	2 70	3	2	9	0 40
78	240	Vsb2	2	2	1	39	1	2	1	2	1 76	3	2	9	0 50
79	241	Vsb3	2	2	1	42	1	2	1	2	2 24	3	2	9	0 25
80	243	Vt5	2	1	0	45	3	4	2	1	0 99	2	2	4	0 30
81	244	Vl 5	2	2	1	56	1	3	1	1	0 54	1	2	3	0 30
82	247	Vh6	3	4	1	49	3	3	1	1	0 48	1	2	5	0 25
83	249	Vh7	2	2	1	45	1	3	1	1	0 45	1	2	3	0 25
84	254	Vms7	3	3	2	71	3	4	2	1	1 95	3	2	6	0 50
85	256	Vms8	3	2	2	42	3	4	2	1	1 68	3	2	6	0 50
86	258	Vd15	3	2	2	79	3	1	1	1	1 30	1	2	3	0 25

			36	37	38	39	40	41	42	43	44	45	46	47	48
Sl No	TCR No	Code for taxa	Colour of stem	Pubescence of stem	Colour of stem hair	Days to flowering	Position of raceme	Colour of flower	Colour of calyx	Colour of corolla	Size of flower bud (l x b)	Size of bracteole	Shape of bracteole	No of flowers/raceme	Keel pocket length (mm)
112	303	Vst3	1	2	2	64	3	3	2	1	0 70	2	1	5	0 25
113	305	Vt7	1	1	0	56	3	3	2	1	0 40	2	2	5	0 20
114	306	Vt8	1	1	0	50	3	3	2	1	0 63	2	2	5	0 10
115	307	Vh8	3	4	1	55	3	3	1	1	0 64	1	2	5	0 20
116	308	Vun3	2	2	2	98	3	5	2	5	5 75	0	0	4	0 00
117	310	Vmu1	3	3	2	127	3	4	1	1	1 65	3	2	5	0 40
118	311	Vtb13	3	3	1	57	3	4	2	3	2 04	3	1	4	0 50
119	313	Vmu2	3	3	2	86	3	4	1	1	1 65	3	2	5	0 25
120	314	Vh9	3	4	1	58	3	3	1	1	0 48	1	2	5	0 25
121	318	Vt9	1	1	0	50	3	3	2	1	1 30	2	2	5	0 30
122	319	Vt10	1	1	0	48	3	3	2	1	0 48	2	2	5	0 30
123	320	Vt11	1	1	0	50	3	3	2	1	0 80	2	2	5	0 25
124	321	Vrs12	2	3	1	52	3	3	2	3	0 45	2	1	7	0 30
125	323	Vh10	2	2	1	55	3	3	1	1	0 48	1	2	8	0 30
126	330	Vug2	2	1	2	58	3	4	1	1	1 10	1	1	4	0 25
127	331	Vug3	2	1	2	58	3	4	1	1	1 10	1	1	4	0 20
128	334	Vug4	2	1	2	51	3	4	1	1	1 32	1	1	4	0 10
129	342	Vtb14	3	3	1	141	3	4	1	1	2 70	3	1	4	0 25
130	345	Vtb15	3	3	1	131	3	4	1	1	3 20	3	1	4	0 30
131	348	Vtb16	3	3	1	116	3	4	1	1	2 04	3	1	4	0 30
132	350	Va	3	3	1	84	3	3	1	1	0 30	2	1	4	0 25
133	384	Vtb17	3	3	1	79	3	4	1	1	1 80	3	1	4	0 50
134	385	Vtb18	3	3	1	74	3	4	2	1	1 43	3	1	4	0 50
35	387	Vd17	2	2	2	104	3	3	1	1	1 32	1	2	5	0 25

			36	37	38	39	40	41	42	43	44	45	46	47	48
Sl No	TCR No	Code for taxa	Colour of stem	Pubescence of stem	Colour of stem hair	Days to flowering	Position of raceme	Colour of flower	Colour of calyx	Colour of corolla	Size of flower bud (l x b)	Size of bracteole	Shape of bracteole	No of flowers/raceme	Keel pocket length (mm)
136	388	Vd18	2	2	2	131	3	3	1	1	1 56	1	2	5	0 30
137	390	Vms20	3	3	2	126	3	4	2	1	1 50	3	2	6	0 50
138	392	Vms21	3	3	2	75	3	4	2	1	1 82	3	2	6	0 50
139	393	Vms22	3	3	2	79	3	4	2	1	1 54	3	2	6	0 60
140	397	Vrs13	2	3	1	63	1	3	2	3	2 08	2	1	7	0 00
141	398	Vd19	2	2	2	114	3	3	1	1	1 56	1	2	5	0 30
142	399	Vtb19	3	3	1	126	3	4	3	1	2 40	3	1	4	0 25
143	400	Vrs14	2	3	1	67	1	3	2	3	1 54	2	1	7	0 20
144	401	Vd20	3	2	2	114	3	1	1	1	0 42	1	2	3	0 20
145	402	Vt12	1	1	0	51	3	3	1	1	0 90	2	2	5	0 20
146	403	Vt13	1	1	0	55	3	3	2	1	0 70	2	2	5	0 10
147	405	V na	1	1	0	127	1	1	1	1	3 24	0	0	1	0 00
148	407	Vd21	2	2	2	144	1	4	2	1	1 92	1	2	5	0 50
149	410	Vp	1	2	2	168	3	5	1	5	5 52	0	0	15	0 00
150	161 A	Vrs15	2	2	1	64	1	2	2	1	1 54	2	1	9	0 30

			49	50	51	52	53	54	55	56	57	58	59	60
Sl No	TCR No	Code for taxa	Colour of peduncle	Pubescence of peduncle	Peduncle length (cm)	No of pods/peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod	Days to first pod maturity	Pubescence of pod	Curvature of Pod	Pod length (cm)	Shape of pod beak
1	1	Vrs1	2	2	11 50	4	2	3	2	76	3	1	4 22	1
2	2	Vst1	2	3	6 80	3	3	2	10	72	1	1	3 30	2
3	3	Vrs2	2	2	11 33	4	2	3	2	68	3	1	4 38	1
4	5	Vrs3	2	2	15 67	4	2	3	2	75	3	1	4 72	1
5	7	Vrs4	2	2	11 50	4	2	3	2	75	3	1	4 18	1
6	8	Vtb1	1	2	18 40	3	2	2	8	100	3	1	6 50	2
7	9	Vd1	1	2	8 50	3	4	3	2	147	1	2	4 40	1
8	10	Vd2	1	2	7 90	3	4	3	2	136	1	2	4 34	1
9	11	Vrs5	2	2	13 27	4	2	3	2	80	3	1	4 40	1
10	12	Vd3	1	2	8 58	3	4	3	2	134	1	2	4 20	1
11	13	Vd4	1	2	8 67	3	4	3	2	147	1	2	5 00	1
12	18	Vug1	1	1	12 00	2	4	3	2	96	1	3	5 90	2
13	20	Vg	1	1	37 00	7	2	4	6	96	1	1	7 70	2
14	24	Vh1	2	3	5 20	3	2	3	1	63	1	1	3 36	1
15	26	Vh2	2	3	11 00	3	2	3	1	92	1	1	5 36	1
16	29	Vh3	2	3	6 50	3	2	3	1	82	1	1	4 08	1
17	60	Vr1	3	3	18 50	7	2	2	2	50	3	1	5 96	1
18	61	Vr2	3	3	11 90	3	2	2	2	50	3	1	5 26	1
19	62	Vr3	2	3	14 00	3	2	2	2	54	3	1	5 80	1
20	66	Vrs6	2	1	5 67	3	3	3	2	56	2	1	4 74	2

			49	50	51	52	53	54	55	56	57	58	59	60
Sl No	TCR No	Code for taxa	Colour of peduncle	Pubescence of peduncle	Peduncle length (cm)	No of pods/peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod	Days to first pod maturity	Pubescence of pod	Curvature of Pod	Pod length (cm)	Shape of pod beak
21	67	Vse1	2	1	8 50	3	3	3	2	65	2	1	5 02	2
22	68	Vse2	2	1	8 83	3	3	3	2	63	2	1	7 14	2
23	69	Vse3	2	1	13 67	3	3	3	2	63	2	1	6 46	2
24	70	Vr4	2	2	14 33	4	2	3	6	48	3	1	6 68	2
25	71	Vse4	1	2	15 40	3	2	2	2	50	3	1	5 80	2
26	72	Vr5	2	2	15 57	4	2	3	3	54	3	1	6 28	2
27	74	Vr6	2	2	13 90	4	2	3	3	56	3	1	6 48	2
28	83	Vt1	1	1	16 33	3	3	2	6	71	1	1	5 70	2
29	84	Vt2	1	1	26 33	3	3	2	6	87	1	1	5 38	2
30	86	Vt3	1	1	19 67	3	3	2	6	71	1	1	5 44	2
31	87	Vu1	1	1	14 33	5	4	1	2	81	1	2	9 38	1
32	88	Vu2	1	1	9 00	5	4	1	2	66	1	2	8 86	1
33	89	Vu3	1	1	13 00	5	4	1	2	82	1	2	8 58	1
34	90	Vu4	1	1	9 67	5	4	1	2	92	1	2	8 50	1
35	91	Vu5	1	1	12 67	5	4	1	2	102	1	2	5 60	1
36	92	Vu6	1	1	14 67	5	4	1	2	67	1	2	8 20	1
37	93	Vu7	1	1	18 67	5	4	1	2	95	1	2	7 00	1
38	94	Vu8	1	1	18 00	5	4	1	2	62	1	2	8 72	1
39	95	Vu9	1	1	12 00	5	4	1	2	102	1	2	6 70	1
40	106	Vd5	1	2	8 90	3	4	3	2	161	1	2	4 00	1
41	121	Vtb2	1	2	20 15	3	2	2	8	100	3	1	5 50	2
42	126	Vd6	1	2	11 60	3	4	3	2	161	1	2	4 40	1
43	141	Vse5	2	2	10 53	4	2	3	2	68	3	1	4 06	1
44	142	Vtb3	1	2	15 00	3	2	2	8	100	3	1	6 10	2

			49	50	51	52	53	54	55	56	57	58	59	60
Sl No	TCR No	Code for taxa	Colour of peduncle	Pubescence of peduncle	Peduncle length (cm)	No of pods/peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod	Days to first pod maturity	Pubescence of pod	Curvature of Pod	Pod length (cm)	Shape of pod beak
45	143	Vd7	1	2	7 33	3	4	3	2	144	1	2	4 20	1
46	144	Vd8	1	2	14 33	3	4	3	2	132	1	2	4 32	1
47	147	Vd9	1	2	7 87	2	4	3	5	92	1	3	5 22	1
48	155	Vms1	1	1	11 33	3	5	3	9	82	4	1	3 50	1
49	156	Vtb4	1	2	24 33	3	2	2	8	92	3	1	5 40	2
50	157	Vms2	1	1	12 17	3	5	3	9	92	4	1	3 78	1
51	158	Vms3	1	1	19 67	3	5	3	9	82	4	1	2 90	1
52	160	Vms4	1	1	11 77	3	5	3	9	92	4	1	3 38	1
53	161	Vv1	1	1	15 67	2	2	3	2	92	1	1	8 00	1
54	162	Vv2	1	1	14 00	2	2	3	2	86	1	1	11 94	1
55	163	Vd10	1	2	7 67	2	4	3	5	92	1	3	4 22	1
56	164	Vtb5	1	2	8 57	3	2	2	8	119	3	1	6 50	2
57	165	Vk	1	3	17 40	5	3	3	6	170	2	1	5 70	1
58	169	Vv3	1	1	13 33	2	2	3	2	103	1	1	7 80	1
59	171	Vms5	1	2	13 17	3	5	3	9	83	4	1	3 76	1
60	174	Vtb6	1	2	19 30	3	2	2	8	71	3	1	5 60	2
61	176	Vtb7	1	2	20 56	3	2	2	8	71	3	1	5 30	2
62	188	Vr7	2	2	12 17	4	2	3	2	83	3	1	4 86	1
63	189	Vtb8	1	2	21 67	3	2	2	8	71	3	1	5 40	2
64	192	Vt4	1	1	17 67	3	3	2	6	65	1	1	4 78	2
65	195	Vtb9	1	2	21 50	3	2	2	8	71	3	1	6 00	2

			49	50	51	52	53	54	55	56	57	58	59	60
Sl No	TCR No	Code for taxa	Colour of peduncle	Pubescence of peduncle	Peduncle length (cm)	No of pods/peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod	Days to first pod maturity	Pubescence of pod	Curvature of Pod	Pod length (cm)	Shape of pod beak
66	199	Vd11	1	2	12 30	3	4	3	2	161	1	2	4 70	1
67	204	Vu10	1	1	9 50	5	4	1	2	102	1	2	11 10	1
68	206	Vtb10	1	2	20 33	3	2	2	8	71	3	1	6 30	2
69	207	Vh4	2	3	10 00	3	2	3	1	64	1	1	4 18	1
70	208	Vun1	1	1	14 60	2	1	3	7	67	1	1	11 80	1
71	214	Vd12	1	2	15 00	3	4	3	2	132	1	2	3 62	1
72	215	Vst2	1	3	7 83	3	3	2	10	76	1	1	3 82	2
73	217	Vv4	1	1	18 50	2	2	3	2	97	1	1	11 32	1
74	230	Vms6	1	1	10 67	3	5	3	9	82	4	1	3 60	1
75	233	Vd13	1	3	10 93	3	4	3	5	71	1	2	3 44	1
76	234	Vd14	1	3	8 50	3	4	3	5	76	1	2	4 22	1
77	238	Vsb1	2	1	11 17	3	3	3	2	68	2	1	6 08	2
78	240	Vsb2	2	1	10 83	3	3	3	2	71	2	1	6 64	2
79	241	Vsb3	2	1	9 00	3	3	3	2	71	2	1	6 42	2
80	243	Vt5	1	1	25 67	3	3	3	5	62	1	1	5 32	2
81	244	Vh5	2	3	13 83	3	2	3	1	71	1	1	3 12	1
82	247	Vh6	2	3	11 83	3	2	2	1	63	1	1	4 08	1
83	249	Vh7	2	3	13 67	3	2	3	1	71	1	1	3 56	1
84	254	Vms7	1	1	14 00	3	5	3	9	82	4	1	3 92	1
85	256	Vms8	1	1	9 33	3	5	3	9	75	4	1	3 92	1
86	258	Vd15	2	2	10 83	2	4	3	5	99	1	3	4 58	1

			49	50	51	52	53	54	55	56	57	58	59	60
Sl No	TCR No	Code for taxa	Colour of peduncle	Pubescence of peduncle	Peduncle length (cm)	No of pods/peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod	Days to first pod maturity	Pubescence of pod	Curvature of Pod	Pod length (cm)	Shape of pod beak
87	259	Vms9	1	1	6 97	3	5	3	9	83	4	1	3 78	1
88	260	Vms10	1	1	7 67	3	5	3	9	80	4	1	4 00	1
89	262	Vms11	1	1	12 43	3	5	3	9	80	4	1	3 86	1
90	265	Vms12	1	1	11 00	3	5	3	9	77	4	1	4 04	1
91	266	Vms13	1	1	8 00	3	5	3	9	76	4	1	3 96	1
92	267	Vms14	1	1	11 33	3	5	3	9	75	4	1	4 00	1
93	268	V	1	1	8 00	3	3	3	2	77	1	1	3 50	1
94	270	Vms15	1	1	12 83	3	5	3	9	80	4	1	3 20	1
95	271	Vms16	1	1	8 50	3	5	3	9	80	4	1	3 38	1
)(	272	Vms17	1	1	10 67	3	5	3	9	76	4	1	3 98	1
)7	273	Vse6	2	1	12 83	3	3	3	2	96	2	1	3 70	2
)8	274	Vd16	3	3	16 40	3	4	3	5	92	1	1	3 70	1
99	275	Vms18	1	1	8 43	3	5	3	9	80	4	1	3 96	1
100	276	Vms19	1	1	9 00	3	5	3	9	76	4	1	3 98	1
101	277	Vtb11	1	2	22 30	3	2	2	8	82	3	1	6 40	2
102	278	Vrs7	2	2	10 50	4	2	3	2	80	3	1	4 46	1
103	279	Vrs8	2	2	15 33	4	2	3	3	80	3	1	4 46	1
104	284	Vun2	1	1	15 60	2	1	3	7	61	1	1	12 46	1
105	290	Vtb12	1	2	10 83	3	2	2	2	85	4	1	4 60	2
106	295	Vt6	1	1	18 17	3	3	3	5	63	1	1	4 90	2
107	297	Vrs9	2	2	10 43	4	2	3	3	83	3	1	4 00	1
108	298	Vu11	1	1	14 50	5	4	1	2	98	1	2	10 80	1
109	300	Vrs10	2	2	17 33	4	2	3	3	77	3	1	4 40	1
110	301	Vrs11	2	2	12 67	4	2	3	3	71	3	1	4 44	1
	302	Vtt	1	2	16 50	5	2	2	8	169	4	1	6 20	2

			49	50	51	52	53	54	55	56	57	58	59	60
Sl No	TCR No	Code for taxa	Colour of peduncle	Pubescence of peduncle	Peduncle length (cm)	No of pods/peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod	Days to first pod maturity	Pubescence of pod	Curvature of Pod	Pod length (cm)	Shape of pod beak
112	303	Vst3	1	1	5 67	3	3	2	10	66	1	1	2 46	2
113	305	Vt7	1	1	20 17	3	3	2	6	71	1	1	4 98	2
114	306	Vt8	1	1	15 33	3	3	2	6	68	1	1	5 16	2
115	307	Vh8	2	3	6 25	3	2	2	1	68	1	1	4 06	1
116	308	Vun3	1	1	13 67	2	1	3	7	113	1	1	11 90	1
117	310	Vmu1	2	3	14 00	3	2	3	9	144	3	1	3 90	2
118	311	Vtb13	1	2	30 33	3	2	2	8	79	3	1	5 90	2
119	313	Vmu2	2	3	15 00	3	2	3	9	95	3	1	4 24	2
120	314	Vh9	2	3	9 67	3	2	2	1	76	1	1	4 08	1
121	318	Vt9	1	1	20 00	3	3	2	6	65	1	1	4 76	2
122	319	Vt10	1	1	21 33	3	3	2	6	71	1	1	4 90	2
123	320	Vt11	1	1	19 50	3	3	2	6	71	1	1	5 32	2
124	321	Vrs12	2	2	13 33	4	2	3	3	71	3	1	4 42	1
125	323	Vh10	1	2	18 50	2	2	2	1	68	1	1	3 16	1
126	330	Vug2	1	1	10 67	2	4	3	2	76	1	3	5 02	2
127	331	Vug3	1	1	9 67	2	4	3	2	77	1	3	4 88	2
128	334	Vug4	1	1	10 33	2	4	3	2	71	1	3	5 20	2
129	342	Vtb14	1	2	10 67	3	2	2	8	79	3	1	5 50	2
130	345	Vtb15	1	2	18 30	3	2	2	8	79	3	1	6 50	2
131	348	Vtb16	1	2	15 33	3	2	2	8	79	3	1	5 04	2
132	350	Va	1	3	3 40	3	3	3	6	102	1	1	5 60	1
133	384	Vtb17	1	2	21 67	3	2	2	8	61	3	1	5 78	2
134	385	Vtb18	1	2	24 67	3	2	2	8	96	3	1	6 02	2
135	387	Vd17	1	2	11 00	3	4	3	2	116	1	2	3 82	1

			49	50	51	52	53	54	55	56	57	58	59	60
Sl No	TCR No	Code for taxa	Colour of peduncle	Pubescence of peduncle	Peduncle length (cm)	No of pods/peduncle	Nature of pod attachment to peduncle	Colour of immature pod	Colour of mature pod	Days to first pod maturity	Pubescence of pod	Curvature of Pod	Pod length (cm)	Shape of pod beak
136	388	Vd18	1	2	10 50	2	4	3	5	93	1	3	3 34	1
137	390	Vms20	1	1	10 67	3	5	3	9	96	4	1	3 80	1
138	392	Vms21	1	1	11 67	3	5	3	9	96	4	1	3 80	1
139	393	Vms22	1	1	9 33	3	5	3	9	99	4	1	3 96	1
140	397	Vrs13	2	2	9 50	4	2	3	3	83	3	1	4 20	1
141	398	Vd19	1	2	12 17	3	4	3	2	132	1	2	4 76	1
142	399	Vtb19	1	2	14 83	3	2	2	8	85	3	1	5 80	2
143	400	Vrs14	2	2	8 83	4	2	3	3	83	3	1	4 24	1
144	401	Vd20	2	2	9 33	2	4	3	5	68	1	3	4 20	1
145	402	Vt12	1	1	39 33	3	4	2	2	80	1	1	5 34	2
146	403	Vt13	1	1	23 00	3	3	2	6	71	1	1	5 24	2
147	405	Vma	1	1	3 60	1	4	2	6	166	2	1	3 30	2
148	407	Vd21	2	2	12 17	3	4	3	2	171	1	2	5 10	1
149	410	Vp	1	3	6 50	3	4	3	4	184	4	1	8 50	1
150	161 A	Vrs15	2	1	8 50	3	3	3	2	89	2	1	5 36	2

			61	62	63	64	65	66	67	68	69	70	71	72
Sl No	TCR No	Code for taxa	Cross section of pod	No of seeds/pod	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Shape of hilum	Hilum length (mm)	Seed yield/plant (g)
1	1	Vrs1	2	12 20	3	Blackish brown	0	0	0 82	2 51	1 98	1	1 59	26 64
2	2	Vst1	2	6 20	3	Cream mottled with black	0	2	1 03	2 56	1 92	3	1 18	1 5
3	3	Vrs2	2	11 60	3	Blackish brown	0	0	0 85	2 57	2 38	1	1 57	37 83
4	5	Vrs3	2	10 80	3	Blackish brown	0	0	0 85	2 55	2 28	1	1 7	40 37
5	7	Vrs4	2	9 20	3	Blackish brown	0	0	1 08	3 01	2 24	1	1 92	66 62
6	8	Vtb1	1	14 20	2	Black	0	1	2 31	3 44	3 36	2	1 88	22 31
7	9	Vd1	1	11 20	3	Greyish green mottled with black	1	2	1 04	2 49	2 12	3	1 07	5 29
8	10	Vd2	1	9 00	3	Greyish green mottled with black	1	2	1 06	3 03	2 05	3	1 48	15 94
9	11	Vrs5	2	9 80	3	Blackish brown	0	0	1 32	2 89	2 4	1	1 69	33 11
10	12	Vd3	1	11 00	3	Greyish green mottled with black	1	2	1 01	2 79	2 2	3	1 6	39 34
11	13	Vd4	1	11 40	3	Greyish green mottled with black	1	2	1 09	3 26	2 27	3	2 1	18 71
12	18	Vug1	2	10 80	4	Mottled black	1	2	0 95	2 97	1 95	1	1 14	22 08
13	20	Vg	2	9 80	3	Black	1	0	3 17	4 31	3 08	1	2 51	211 12
14	24	Vh1	2	8 20	3	Greyish mottled with black	0	2	0 52	2 3	1 77	3	0 92	0 52
15	26	Vh2	2	8 40	3	Greyish mottled with black	0	2	0 63	2 44	2 01	3	0 94	1 93
16	29	Vh3	2	9 20	3	Greyish mottled with black	0	2	0 61	2 4	1 86	3	1 12	5 42
17	60	Vr1	2	10 80	2	Green	0	0	2 31	3 69	2 8	1	1 75	8 11
18	61	Vr2	2	11 20	2	Green	0	0	1 77	2 94	2 7	1	2 5	471
19	62	Vr3	2	11 00	2	Intermediate green	0	0	2 17	3 85	2 79	1	1 88	27 55
20	66	Vrs6	2	2 00	3	Blackish brown	0	0	0 67	2 5	2 09	1	1 53	26 43

			61	62	63	64	65	66	67	68	69	70	71	72
Sl No	TCR No	Code for taxa	Cross section of pod	No of seeds/pod	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Shape of hilum	Hilum length (mm)	Seed yield/plant (g)
21	67	Vse1	2	11 00	2	Black	0	0	0 96	2 94	2 42	2	1 48	35 69
22	68	Vse2	2	14 80	2	Black	0	0	1 24	3 53	2 28	2	1 23	16 72
23	69	Vse3	2	14 40	2	Black	0	0	1 39	2 57	2 66	2	1 39	47 1
24	70	Vr4	2	11 40	2	Green	0	0	2 27	3 38	2 96	1	1 48	16 4
25	71	Vse4	2	12 60	2	Black	0	0	1 17	2 37	2 27	2	1 27	20 67
26	72	Vr5	2	10 00	2	Green	0	0	3 13	3 9	3 24	1	1 89	4 5
27	74	Vr6	2	12 60	2	Light green	0	0	1 96	3 59	2 59	1	1 59	10 41
28	83	Vt1	2	13 40	3	Blackish grey	0	1	0 94	2 89	1 93	1	1 67	11 8
29	84	Vt2	2	13 60	3	Blackish grey	0	1	0 83	2 77	1 97	1	1 51	9 79
30	86	Vt3	2	12 60	3	Blackish grey	0	1	0 93	3 03	2 26	1	1 58	17 91
31	87	Vu1	1	7 20	4	Greenish brown	1	0	6 13	7 88	3 79	3	3 78	95 98
32	88	Vu2	1	7 40	4	Greenish brown	1	0	5 72	6 87	3 68	3	3 25	75 51
33	89	Vu3	1	8 00	4	Light greenish brown	1	0	4 63	6 79	2 84	3	2 88	55 22
34	90	Vu4	1	6 00	4	Light greenish brown	1	0	5 55	6 74	3 47	3	3 47	55 95
35	91	Vu5	3	5 80	4	Green	1	0	5 77	7 04	4 33	3	3 58	125 7
36	92	Vu6	1	7 06	4	Black	1	2	4 57	6 79	3 97	3	3 1	73 3
37	93	Vu7	2	7 20	4	Green sh yellow	1	0	4 89	5 92	3 27	3	2 98	85 1
38	94	Vu8	1	7 80	4	Brown	1	0	7 53	8 32	4 18	3	4 04	43 36
39	95	Vu9	2	6 00	4	Mottled green	1	0	6 56	6 91	4 01	3	3 4	49 12
40	106	Vd5	1	9 60	3	Grey sh green mottled with black	1	3	0 99	3 03	2	3	2 04	2
41	121	Vtb2	1	12 00	2	Black	0	1	1 6	3 18	2 33	2	1 87	22 42
42	126	Vd6	1	10 40	3	Greyish green mottled w th black	1	3	0 89	2 82	1 87	3	1 59	6 13
43	141	Vse5	2	10 40	2	Black	0	0	0 82	2 6	2 11	2	1 67	63 09
	42	V b3	1	12 00	2	Black	0	1	1 64	3 11	2 87	2	1 87	6 13

			61	62	63	64	65	66	67	68	69	70	71	72
Sl No	TCR No	Code for taxa	Cross section of pod	No of seeds/pod	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Shape of hilum	Hilum length (mm)	Seed yield/plant (g)
45	143	Vd7	2	9 60	3	Greyish green mottled with black	1	2	0 93	2 63	1 85	3	1 61	41 48
46	144	Vd8	2	7 80	3	Greyish green mottled with black	1	3	0 98	2 99	1 82	3	1 95	49 47
47	147	Vd9	2	10 20	3	Greyish green mottled with black	1	3	1 08	3 07	1 9	3	1 9	58 83
48	155	Vms1	2	8 00	1	Mottled blackish brown	0	2	1 47	3 01	2 67	3	2 28	46 26
49	156	Vtb4	1	9 80	2	Black	0	1	1 27	2 93	2 3	2	1 34	37 86
50	157	Vms2	2	9 00	1	Mottled blackish brown	0	2	1 41	2 99	2 74	3	2 03	41 94
51	158	Vms3	2	6 40	1	Mottled blackish brown	0	0	1 24	2 89	2 63	3	2 14	43 86
52	160	Vms4	2	9 00	1	Mottled blackish brown	0	2	2 85	3 92	3 11	3	2 17	67 51
53	161	Vv1	2	1 20	5	Blackish brown	1	0	1 29	4 13	2 19	1	2 03	1 85
54	162	Vv2	2	16 00	5	Blackish brown	1	0	1 83	4 34	2 52	1	2 03	12 67
55	163	Vd10	2	7 00	3	Greyish green mottled with black	1	3	0 72	3 17	1 94	3	2 16	18 97
56	164	Vtb5	1	12 60	2	Black	0	1	1 59	3 14	3 06	2	1 79	14 55
57	165	Vk	2	10 00	3	Blackish brown	0	0	4 1	4 4	3 46	2	1 52	2 81
58	169	Vv3	1	12 20	5	Blackish brown	1	0	1 06	4 18	2 81	1	2 06	1 47
59	171	Vms5	2	8 20	1	Mottled blackish brown	0	0	1 31	2 94	2 46	3	2 35	63 61
60	174	Vtb6	1	12 40	2	Black	0	1	0 88	2 88	2 15	2	1 39	16 15
61	176	Vtb7	1	12 00	2	Blackish grey	0	1	1 07	2 98	2 4	2	1 71	15 43
62	188	Vr7	2	9 20	2	Intermediate green	0	0	1 71	3 33	2 18	1	1 74	28 93
63	189	Vtb8	1	9 80	2	Blackish grey	0	1	0 67	2 92	2 31	2	1 28	18 04
64	192	Vt4	2	10 80	3	Blackish grey	0	1	0 8	2 45	2 22	1	1 32	23 66
65	195	Vtb9	2	13 00	2	Black	0	1	1 47	3 11	2 24	2	2 63	36 73

			61	62	63	64	65	66	67	68	69	70	71	72
Sl No	TCR No	Code for taxa	Cross section of pod	No of seeds/pod	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Shape of hilum	Hilum length (mm)	Seed yield/plant (g)
66	199	Vd11	1	9 60	3	Greyish green mottled with black	1	2	0 9	2 83	2 21	3	1 97	20 52
67	204	Vu10	1	9 60	4	Light greenish brown	1	0	7 01	7 39	4 29	3	3 25	191 41
68	206	Vtb10	2	14 00	2	Black	0	0	1 63	3 07	2 84	2	2 31	33 7
69	207	Vh4	2	9 80	3	Greyish mottled with black	0	3	0 67	2 6	2 08	3	1 23	6 29
70	208	Vun1	1	11 00	5	Chocalate brown	0	0	11 34	7 44	5 55	1	3 61	25 35
71	214	Vd12	2	9 30	3	Greyish green mottled with black	1	3	1	2 82	1 97	3	1 83	43 89
72	215	Vst2	2	8 00	3	Cream mottled with black	0	2	0 8	2 75	1 91	3	1 16	16
73	217	Vv4	1	18 60	5	Blackish brown	1	0	1 73	4 84	3 02	1	2 18	11 68
74	230	Vms6	2	8 00	1	Mottled blackish brown	0	2	1 63	3 19	2 63	3	1 6	25 3
75	233	Vd13	2	8 20	3	Greyish green mottled with black	1	2	0 68	2 39	1 82	3	1 48	42 67
76	234	Vd14	2	8 60	3	Greyish green mottled with black	1	2	0 8	2 59	2 11	3	1 4	55 26
77	238	Vsb1	2	10 60	3	Mottled grey	0	0	1 57	2 87	2 51	2	1 00	33 99
78	240	Vsb2	2	14 40	3	Black	0	0	1 45	2 6	2 3	2	0 80	23 30
79	241	Vsb3	2	13 60	3	Black	0	0	1 35	2 74	2 2	2	0 90	14 60
80	243	Vt5	2	11 00	3	Blackish grey	0	1	0 89	2 9	1 99	1	1 6	11 27
81	244	Vh5	2	8 60	3	Greyish mottled with black	0	2	0 85	2 13	1 52	3	0 83	23 39
82	247	Vh6	2	10 00	3	Greyish mottled w th black	0	2	0 63	2 36	1 71	3	1 12	23 48
83	249	Vh7	2	8 60	3	Greyish mottled with black	0	3	0 62	2 38	1 98	3	0 99	18 31
84	254	Vms7	2	7 20	1	Mottled blackish brown	0	2	1 57	3 16	3 12	3	2 32	443
85	256	Vms8	2	7 00	1	Mottled blackish brown	0	2	1 92	3 49	2 75	3	2 82	1090
86	258	Vd15	2	8 80	3	Greyish green mottled with black	1	2	0 89	2 79	2 45	3	1 64	46 28

			61	62	63	64	65	66	67	68	69	70	71	72
Sl No	TCR No	Code for taxa	Cross section of pod	No of seeds/pod	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Shape of hilum	Hilum length (mm)	Seed yield/plant (g)
87	259	Vms9	2	9 20	1	Mottled blackish brown	0	2	1 56	2 99	2 6	3	2 24	65 2
88	260	Vms10	2	9 60	1	Mottled black sh brown	0	2	1 32	3 03	2 49	3	2 68	60 96
89	262	Vms11	2	9 20	1	Mottled blackish brown	0	2	1 44	2 87	2 41	3	2 4	60 96
90	265	Vms12	2	9 20	1	Mottled blackish brown	0	2	1 79	3 3	2 64	3	1 99	79 45
91	266	Vms13	2	8 00	1	Mottled blackish brown	0	2	1 7	3 18	2 51	3	1 82	969
92	267	Vms14	2	8 80	1	Mottled blackish brown	0	2	1 68	3 18	2 88	3	2 45	79 21
93	268	V	2	8 60	3	Mottled black	0	2	0 54	2 33	1 75	3	1 06	20 75
94	270	Vms15	2	7 60	1	Mottled blackish brown	0	2	1 64	3 04	2 74	3	2 17	95 38
95	271	Vms16	2	5 80	1	Mottled black	0	2	0 8	3 01	2 32	3	2 22	32 05
96	272	Vms17	2	8 60	1	Mottled blackish brown	0	2	1 73	3 44	2 86	3	2 34	130 26
97	273	Vse6	1	10 00	2	Black	0	0	1 71	3 08	2 87	2	1 47	21 89
98	274	Vd16	2	9 60	3	Greyish green mottled with black	1	2	0 84	2 7	1 7	3	2 05	87 52
99	275	Vms18	2	8 80	1	Mottled blackish brown	0	2	1 49	2 94	2 48	3	2 31	78 27
100	276	Vms19	2	8 80	1	Mottled blackish brown	0	2	1 53	2 93	2 5	3	1 6	59 41
101	277	Vtb11	1	13 60	2	Black	0	0	1 71	3 18	2 35	2	1 84	38 27
102	278	Vrs7	2	10 80	3	Blackish brown	0	0	0 8	2 78	1 95	1	1 52	32 00
103	279	Vrs8	2	12 40	3	Blackish brown	0	0	0 85	2 48	2 18	1	1 68	28 25
104	284	Vun2	1	10 60	5	Cream	0	0	4 28	5 48	3 5	1	2 25	24 24
105	290	Vtb12	2	12 00	2	Black	0	0	0 77	2 58	2 04	2	1 55	5 51
106	295	Vt6	2	13 60	3	Blackish grey	0	1	0 76	2 58	1 89	1	1 56	21 4
107	297	Vrs9	2	10 00	3	Blackish brown	0	0	1	2 42	2 3	1	1 88	68 90
108	298	Vu11	1	7 00	4	Green	1	0	5 94	6 67	3 81	3	2 78	170 73
109	300	Vrs10	2	11 60	3	Blackish brown	0	0	0 83	2 57	2 22	1	1 94	47 78
110	301	Vrs11	2	10 40	3	Black sh bro vn	0	0	1 21	3	2 67	1	2 39	70 63
	302	V	2	13 00	3	Black	0	0	1 35	3 4	2 73	2	1 99	16 3

			61	62	63	64	65	66	67	68	69	70	71	72
Sl No	TCR No	Code for taxa	Cross section of pod	No of seeds/pod	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Shape of hilum	Hilum length (mm)	Seed yield/plant (g)
112	303	Vst3	2	6 40	3	Cream mottled with black	0	2	0 45	2 1	1 81	3	1 06	2 31
113	305	Vt7	2	9 40	3	Blackish grey	0	1	0 9	2 61	1 97	1	1 2	11 98
114	306	Vt8	2	1 40	3	Blackish grey	0	1	0 98	2 95	2 01	1	1 51	33 09
115	307	Vh8	2	9 40	3	Greyish mottled with black	0	2	0 55	2 12	1 55	3	0 94	15 93
116	308	Vun3	1	12 00	5	Cream	0	0	4 87	5 96	4 15	1	2 88	55 7
117	310	Vmu1	2	6 20	3	Mottled black	0	0	2 83	3 97	2 85	3	2 41	60 7
118	311	Vtb13	1	13 60	2	Black	0	0	1 46	3 11	2 86	2	1 54	116 4
119	313	Vmu2	2	5 60	3	Blackish brown	0	0	4 56	4 94	3 67	3	3 41	126 29
120	314	Vh9	2	11 40	3	Greyish mottled with black	0	2	0 54	2 17	1 76	3	0 91	7 34
121	318	Vt9	2	11 00	3	Black sh grey	0	1	0 81	2 55	1 98	1	1 55	25 55
122	319	Vt10	2	11 60	3	Blackish grey	0	1	0 87	2 57	2 07	1	1 47	21 4
123	320	Vt11	2	12 20	3	Blackish grey	0	1	0 88	2 46	1 92	1	1 59	17 21
124	321	Vrs12	2	10 60	3	Blackish brown	0	0	0 95	2 61	2 35	1	2 24	31 50
125	323	Vh10	2	9 00	3	Greyish mottled with black	0	2	0 49	2 03	1 91	3	0 93	2 79
126	330	Vug2	2	10 20	4	Black	1	3	0 95	3 03	2 18	1	1 67	18 49
127	331	Vug3	2	11 20	4	Black	1	3	1 22	2 93	2 42	1	1 76	22 23
128	334	Vug4	2	10 80	4	Black	1	3	1 27	3 91	2 43	1	1 56	21 63
129	342	Vtb14	1	12 00	2	Black	0	0	1 53	3 13	2 77	2	1 46	37 33
130	345	Vtb15	1	11 00	2	Black	0	0	1 83	3 64	3 07	2	2 38	23 81
131	348	Vtb16	1	10 00	2	Black	0	0	1 24	3 32	2 8	2	2	21 75
132	350	Va	2	4 00	4	Intermediate green	1	0	2 00	4 16	2 08	1	1 58	0 28
133	384	Vtb17	2	10 40	2	Black	0	1	1 45	3 04	2 85	2	1 82	148 54
134	385	Vtb18	2	11 00	2	Black	0	1	1 42	2 89	2 02	2	1 67	161 08
135	387	Vd17	1	9 60	3	Greyish green mottled w th black	1	2	0 82	2 5	2 16	3	1 68	26 06

			61	62	63	64	65	66	67	68	69	70	71	72
Sl No	TCR No	Code for taxa	Cross section of pod	No of seeds/pod	Shape of seed	Colour of seed	Lustre on seed surface	Mottling on seed surface	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Shape of hilum	Hilum length (mm)	Seed yield/plant (g)
136	388	Vd18	2	8 40	3	Greyish green mottled with black	1	2	0 84	2 79	1 83	3	1 72	28 36
137	390	Vms20	2	7 20	1	Mottled blackish brown	0	2	1 47	3 27	2 99	3	2 42	27 28
138	392	Vms21	2	7 40	1	Mottled blackish brown	0	2	1 34	3 07	3 22	3	2 37	98 32
139	393	Vms22	2	7 80	1	Mottled blackish brown	0	2	1 46	3 26	3 01	3	2 21	82 78
140	397	Vrs13	2	9 20	3	Blackish brown	0	0	0 79	2 62	2 33	1	1 89	15 99
141	398	Vd19	1	8 20	3	Greyish green mottled with black	1	2	0 98	2 73	2 55	3	1 72	18 12
142	399	Vtb19	1	11 80	2	Black	0	1	1 5	3 16	3 22	2	1 46	97 27
143	400	Vrs14	2	10 40	3	Blackish brown	0	0	0 74	2 43	2 22	1	1 83	39 36
144	401	Vd20	2	10 20	3	Greyish green mottled with black	1	2	1 03	2 73	2 15	3	1 71	48 56
145	402	Vt12	2	12 60	3	Blackish grey	0	1	0 84	2 58	1 91	1	1 64	15 12
146	403	Vt13	2	10 80	3	Blackish grey	0	1	0 75	2 35	1 9	1	1 56	15 95
147	405	Vma	2	5 30	1	Brown	0	0	4 00	5 12	4 55	2	2 89	0 20
148	407	Vd21	1	9 00	3	Greyish green mottled with black	1	3	1 29	3 26	2 83	3	1 58	48 16
149	410	Vp	2	10 00	1	Brown	0	0	6 00	5 95	4 46		2 94	0 42
150	161 A	Vrs15	2	13 40	3	Blackish brown	0	0	0 81	2 52	2 17	1	1 13	32 08