EFFECT OF ALPHA AMYLASE ON SEED GERMINATION IN MUNG BEAN *(Vigna radiata* L.)

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B.Sc. (Agri.)

MASTER OF SCIENCE

IN

AGRICULTURE

AGRICULTURE BOTANY

(SEED TECHNOLOGY)

DEPARTMENT OF AGRICULTURE BOTANY (SEED TECHNOLOGY)

COLLEGE OF AGRICULTURE, PARBHANI

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PARBHANI–431402 (M.S.), INDIA.

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EFFECT OF ALPHA AMYLASE ON SEED GERMINATION IN MUNG BEAN *(Vigna radiata* L.)

BY

SHETE PRUTHVIRAJ SANJAY

B.Sc. (Agri.)

A thesis submitted to

Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani

In partial fulfilment of the requirement for the degree of

MASTER OF SCIENCE

IN

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2022

DECLARATION BY THE CANDIDATE

I hereby declare that the thesis entitled **"EFFECT OF ALPHA AMYLASE ON SEED GERMINATION IN MUNG BEAN *(Vigna radiata* L.)"**, submitted by me is based on the actual work carried out by me under the guidance and supervision of **Dr. S. V. Kalyankar**. The extent of information derived from the existing literature have been duly cited and referenced. The existing research work or its any part is not submitted anywhere else for the award of any degree or diploma.

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Place: PARBHANI

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Research Guide

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This is to certify that the thesis entitled, **"EFFECT OF ALPHA AMYLASE ON SEED GERMINATION IN MUNG BEAN (*Vigna radiata* L.)"** submitted by **Shete Pruthviraj Sanjay Reg. No: 2020A/46M** in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **Agricultural Botany (Seed Technology)** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani has been approved by the Student's Advisory Committee after viva voce examination of the student in collaboration with the External Examiner.

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(Shete Pruthviraj)

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ABBREVATIONS

Agric.	:	Agricultural
%	:	Percent
g	:	Gram
B.P.	:	Better parent
Mg	:	Milligram
C.D.	:	Critical differences
cm	:	Centimeter
Cov.	:	Co-variance
D.F.	:	Degree of freedom
YVMV	:	Yellow vein mosaic virus
SC	:	Standard check
et al	:	And others
F_1	:	First filial generation
FYM	:	Farm Yard Manure
gm	:	Gram
GCA	:	General Combining Ability
SCA	:	Specifi Combining Ability
GPM	:	Germplasm
Ha	:	Hectare
i.e.	:	That is
Improv.	:	Improvement
Inter.	:	International
IC	:	Indigenous collection
SE	:	Standard error
kg/ha	:	Kilogram per hectare
L x T	:	Line x Tester
MP	:	Mid parent

THESIS ABSTRACT

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Title of the thesis	:	Effect of alpha amylase on seed germination in mung bean *(Vigna radiata* L.*)*
Name of the student	:	Shete Pruthviraj Sanjay
Full Name of Research Guide	:	S. V. Kalyankar
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ABSTRACT

The present investigation entitled "**Effect of alpha amylase on seed germination in mung bean *(Vigna radiata* L.*)***" comprised of 12 genotypes including 5 checks *viz;* BM-4, BPMR-145, BM-2003-2, Vaibhav & Utkarsh was evaluated during *kharif* 2021 at VNMKV, Parbhani. Observations were recorded on the characters *viz;* days to 50% flowering, days to maturity, plant height, days required for shattering, number of primary branches per plant, number of pods per cluster, number of pods per plant, length of pod, number of seeds per pod, 100 seed weight, seed yield / plant (g), harvest index, germination percentage, root and shoot length, vigor index I, seed hardness (kg/cm^2), alpha amylase (mg/g), seedling dry wt (g), vigor index II, pod opening time collected and analyzed for analysis of variance, correlation and enzyme activity. The most of the cases, the genotypic correlation coefficients were found to be higher magnitude than the corresponding phenotypic one.

The mean values of observation recorded were subjected to analysis of variances for Randomized Block Design in individual season and pooled (Table 4.1) It was revealed that mean squares due to genotypes found significant for all the characters in all environments over a pooled analysis.

The variation due to genotypes were significant for all the characters under study both at 5% and 1% probability levels in both season. The significant differences in characters indicate the presence of variability in experimental material.

In genotypic correlation, the seed yield character of the study recorded significant positive correlation with primary branches per plant, days to maturity, days required for shattering, number of pods per cluster, number of pods per plant and 100 seed weight while, it was non-significantly positive correlated to the number of seeds per pod, root and shoot length. It also reported non-significant negative correlation with days to 50% flowering, plant height, length of pod and harvest index. The number of primary branches might be developed into more number of pod clusters which resulted in high seed yield per plant.

The enzyme α-amylase showed significant positive correlation with germination percentage, time to opening of pods, vigour index I and vigour index II. Enzyme α-amylase estimated high range of positive correlation with germination percentage, time to opening of pods, vigour index I & II. This indicates the strong association of enzyme α-amylase with germination percentage, time to opening of pods, vigour index I & II. It means increase in enzyme activity of α-amylase with increased germination percentage, time to opening of pods, vigour index I, vigour index II and *vice-versa*.

In phenotypic correlation, the seed yield character of the study recorded significant positive correlation with primary branches per plant, days to maturity, days required for shattering, number of pods per cluster, number of pods per plant, 100 seed weight, root and shoot length while it was non-significantly positive correlated to the number of seeds per pod. It also reported significant negative correlation with length of pod and seed hardness. However, it also reported non-significant negative correlation with days to 50% flowering and plant height. The number of primary branches might be developed into more number of pod clusters which resulted in high seed yield per plant.

The enzyme α-amylase showed significant positive correlation with germination percentage, time to opening of pods, vigour index I and vigour index II. Enzyme α-amylase estimated high range of positive correlation with germination percentage, time to opening of pods, vigour index I & II.

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It mean increase in enzyme activity of α-amylase with increased germination percentage, time to opening of pods, vigour index I, vigour index II and *vice-versa*.

Key words: greengram, alpha amylase, correlation

CHAPTER -I

INTRODUCTION

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INTRODUCTION

Mung bean is a legume of family Fabaceae, sub family Papilionaceae, genus *Vigna* and species *radiata*. This family is a wide spread family as it occupies the third largest family of flowering plant with approximately 650 genera and nearly 20,000 species (Doyle,1994). Green gram is alternatively known as golden gram, mungbean, moong bean, haricot mungo, mash etc. It is an annual, semi erect to erect or sometimes twining, 25-100 cm tall, deep rooted herbaceous plant (Baldev,1988). It can grow under drought stress conditions, where, the short time is available for growth. It grows well under both irrigated as well as rainfed conditions. Salt affected soils are fit for its production, while, it cannot grow well in waterlogged condition (Yadave *et al*.,1998).

Somatic chromosome number of green gram is 2n=24. It wasdomesticated in Persia (Iran). Its progenitor is *Vigna radiata* var. soblobata. It can be cultivated as *kharif* as well as summer crop. The first fortnight of July is the optimum time for *kharif* sowing and from March to April is optimum time for summer sowing.

Green gram is an important pulse crop ranked as the second most drought resistant crop after soybean. It has more protein content and better digestibility than any other pulse crop (Tabasum *et al*., 2010). Green gram originated in India where it has been cultivated for millennia. It spread, in early times, to other Asian countries and later to Africa, Australia, the Americas and West Indies. India is the largest producer, followed by China. It's also grown in many tropical African countries.

Green gram is an important crop in India. It can be used in both sweet and savory dishes. It can also be used for extracting starch or ground into flour called gren gram flour or green moong dal flour. The dried split seeds are pale yellow in colour and are called, dal or dhal. In India and Pakistan the split seeds are cooked as dal (green gram soup or sauce). The split skinless seedscan also be fried and salted and eaten as a snack. Cooked split seeds can also blended with liquid, sweetened and served as a beverage. Immature pods and young leaves are eaten as a vegetable. The haulms are used as fodder and the husks and split beans are a useful livestock food. The crop is also grown for hay, green manure and as cover crop (Duke, 1981).

Green gram grains are having 51% carbohydrates, 26% protein, 10% moisture and 3% vitamin. The residues of green gram are also used as feed for animals and enhance the soil fertility as well (Asaduzzaman, 2008). Green gram is rich source of nutrients including manganese, potassium, copper, zinc and vitamin B complex. They are also high in protein and dietary fiber. Low intake of pulses ultimately leads to the chronic malnutrition among growing population in the developing countries. The recommended dietary allowances for adult male and female are 60 mg and 55 mg day^{-1}.

The $capita^{-1}$ availability of pulses is @ 42 g day^{-1}. This crop can be use for both seed and forage production. It plays an important role not only in human diet, but also in improving the soil fertility by fixing atmospheric nitrogen into available form with the help of *Rhizobia* species present in the nodule of its roots (Ashraf *et al*., 2003). Marathwada region of Maharashtra state is known for the cultivation of *kharif* pulses particularly redgram, greengram and blackgram.

Keeping the above facts in view the present investigation entitled "**Effect of alpha amylase on seed germination in mungbean**" with the following objectives:

1. Effect of alpha amylase on seed germination in mungbean
2. To study the enzyme responsible for germination of seed.
3. To study Correlation studies of enzyme on seed quality.

CHAPTER -II

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

The genus *Vigna* composed of more than 150 species that are of considerable economic importance in many developing countries (Polhill and Van der Maesen, 1985). Mung bean (*Vigna radiata* (L.) Wilczek), Urdbean (*Vigna mungo* (L.) Hepper) and Cowpea (*Vigna unguiculata* (L.) Walp.), are key dietary staples for millions of people. Additionally, Adzuki beans (*Vigna angularis* (Wild.) Ohwi and Ohashi), Bambara groundnuts (*Vigna subterranea* (...) Verdn.), Moth bean (*Vigna aconitifolia* (Jacq.) Marechal) and Rice bean (*Vigna umbellata* (Thunb.) Ohwi and Ohashi) are also consumed in manycountries.

The presumed progenitor of mung bean is the wild form *Vigna radiata* var. *sublobata* (Roxb) Verdcourt, which is widely distributed across the Old World tropics from Western Africa to Northern Australia and Papua NewGuinea (Tomooka et al., 2002). Archaebotanical finds and literary records suggest that mung bean was domesticated in India where wild mung bean is widely distributed (Smartt, 1990).

2.1 Effect of *α*-amylase on seed germination in mungbean (*Vigna radiata* L.):

Bain and Mercer (1966) studied the cotyledons in germinatingseeds and seedling of pea and concluded that the starch is usually hydrolyzed during germination by α-amylase and soluble sugar is used as energy for growing embryo and ultimately resulted in seedling growth.

Abdul-Baki and Anderson (1972) studied physiological and biochemical deterioration of seeds and they showed a correlation between loss of viability with declining in enzyme activity. They observed in some cases decline in enzyme activity leads to death of embryo also.

Dyer and Movellie (1976) studied distribution and activities of α- amylase and β-amylase in germinating corn seed and reported that the germination of cereals results in drastic increased in α-amylase activity.

Wadhwa *et al.* (1988) reported that encapsulation of groundnut seed with nitrocellulose (NC) or ethylene cellulose (EC) has some profound effects on the mobilization of reserve material duringseed germination. Seed encapsulation, in general, increase in lipase, α- amylase and invertase activity and decrease the protease activity as observed by low protein degradation during early stages of germination (0-9 days after sowing). Encapsulation with EC enhances the activity of isocitrate lyase and that with NC increased the rate of starch and lipid degradation and the transport of hydrolysis to growing axis.

Shingeshi *et al.* (1991) reported that the changes in the activity of α-amylase in rice *(Oryza satiua* L.) grain during 18 days germination in a dark room. The effect of α-amylase activity was studied in vitro, α- amylase activity was detected in rice on fourth day and increased markedly from the 12^{th} day and 16^{th} day germination, α- amylase activity was influenced by both the pH and phytic acid concentration in the assay system, α-amylase activity was lowered by 23%, 93% and 52% at pH 4.0, 5.0 and 6.0, respectively.

Desai (2004) mentioned that starch is the major reserve carbohydrate present in most seeds. Starch generally observed in the form of amylose and amylopectin which are hydrolytically degraded by α and β- amylases.

Rahman *et al*. (2009) investigated that enzyme activity and degradation of seed storage in varieties of chickpea seed at different germinating period. During the germination the seed storage substance is used for seedling growth and some hydrolytic enzymes such as amylase, invertase, protease and lipase are activated. These enzyme activities were found correlated with germination percentage, vigour index and development.

2.2 To study enzyme responsible for germination of seed:

Mohankumar and Manonnmani (2011) found that the enhancement in α-amylase activity in primed seed of sunflower may attribute to proper hydration during imbibitions , which leads to faster germination , increased uniformity of germination and higher seedling dry weight.

Ghavidel and Mehdi (2011) proved that untreated, soaked and germinated (for 24, 48 and 72 hrs) legume seeds were analyzed for phytase, α-amylase and protease activities. Enzymes activities increased on pre - germination soaking, except for phytase activity of chickpea, which did not differ significantly. Enzymatic activities of all legumes improved significantly and reached maximum during the course of germination up to 72 hrs. However, maximum protease activity in mung bean was at 48 hrs germination and declined thereafter. Germination as a biotechnological technique improved enzymatic activities in all legumeseeds.

Deshmukh (2013) studied that the freshly harvested seeds of soybean varieties, MAUS-71 and JS-335 were used for the storage study up to 120 days for seed quality and biochemical parameters. The study revealed that, the soybean variety JS-335 had higher α- amylase activity of seed during storage than variety MAUS-71 at 0, 60, 120 days to storage and α- amylase activity decreases with increase in storage period up to 120 days.

Chandrika *et al.* (2013) concluded that enzyme activity plays a key role in each stage of plant development starting from the initial seed germination responses. The enzyme showed highest amount of total antioxidant activity of 304μg/ml in partially purified germinated seed. Germinated seeds have highest enzymatic activity which can be considered for several industrial purposes.

Savitha and Chandra (2013) reported that the change in the activity of α-amylase, β-amylase and proteases involved in the breakdown of stored carbohydrates, proteins in cereals during soaking and the 1st week of germination. Enzyme activities increased significantly on pre germination, soaking and reached maximum during the course ofgermination (0-8 days). Maximum α-amylase was observed on 6 day, β- amylase 4-6 day and protease on 2 day of germination.

2.3 Correlation studies of enzyme on seed quality:

The extent and nature of association between yield and its component traits help breeders to ascertain the real components of yield and effective basis of phenotypic selection. Estimates of correlation coefficient are the measures of association between characters and provide the basic information in identifying characters that have little or no importance in the selection programme. Correlation studies measure only mutual association between two traits and it does not imply the cause and effect of relationship. Selection procedure is more difficult in a trait, where heritability is low or is not precisely measurable. Indirect selection in such a situation is more effective and study of correlation among different economic traits are therefore, essentialfor an effective selection programme because selection for one or more trait results in correlated response for several other traits (Scarle, 1965) and sequence of variation will also be influenced (Waddington and Robertson, 1966).

Hence, the knowledge of genotypic and phenotypic correlation between yield and its contributing characters is very essential. The path coefficient analysis elucidates the intrinsic nature of observed association between yield and its attributes. Path analysis provides estimates for direct and indirect causes of yield (Wright, 1921).

Dewey and Lu (1959) used correlation coefficient for the first time in plants for path analysis. The extent and nature of association between yield and its component traits help breeders to ascertain the real components of yield and effective basis of phenotypic selection. Path coefficient analysis has been found useful direct and indirect causes of association and allows a detailed examination of specific forces acting to produce a given correlation and measures the relative importance of each causal factor.

Study of direct and indirect effects of yield components can provide the basis for its successful breeding program and hence the problem of yield increase can be more effectively tackled on the basis of performance of yield components and selection for closely related characters, so selection for high yield genotypes can be done through yield components. Correlation analysis provides a good measure of the association between characters and facilitates identification of important characters for effective selection for increasing yield.

The important yield components in mung bean are: harvested plant number per unit area, number of pods per plant, grains per pod, and weight of grain (Kuo, 1998), that many research projects have been done to study the relationships among important characteristic affecting grain yield in mung bean (Ghafoor *et al.*, 1990; Khattak et al., 2001; Malhotra et al., 1974; Yucel, 2004). Correlation measures the actual relationship between various plant characters and helps the plant breeder in fixing selection criteria for grain yield in parental lines and segregating populations. Correlation coefficient reveals the type, nature and magnitude of association between any pair of characters.

Phenotypic correlation is the association between two characters, which can be directly observed and is subjected to changes in the environment.

It measures the environmental deviations together with non-additive gene action. Genotypic correlation is the correlation of the breeding values i.e., additive and (additive x additive) gene effects (Falconer, 1989). Knowledge of the association of yield components with each other and with yields is helpful in improvement of yield for which direct selection is not effective. According to Singh and Malhotra (1970) genotypic correlation coefficients were higher than the phenotypic correlation coefficients. Seed yield in mung bean was found to be significantly associated with number of clusters per plant, number of pods per plant, pod length, seeds per pod and seed size.

Singh and Singh (1973) observed positive correlation of seed yield with number of pods and number of clusters per plant. The number of pods per plantwas the major contributing factor for yield, while number of clusters per plant influenced the yield via number of pods per plant.

Giriraj and Vijaykumar (1974) reported that, sced yield was positively correlated with days to 50% flowering plant height, number of pods per plant and seeds per pod. The character 100-seed weight exhibited significant positivecorrelation with pod length but was negatively correlated with seed yield, days to 50% flowering and plant height. Further they found strong positive correlation of pods per plant with plant height and days to flowering.

Malhotra *et al*., (1974) showed that positive association of seed yield with days to maturity, plant height, number of pods and pod length, whereas negative association with grain weight were observed.

Singh and Chaudhary (1977) recorded positive significant association ofseed yield with number of primary branches per plant, number of clusters per plant, number of pods per cluster and number of pods per plant.

Rathnaswamy *et al*., (1978) observed high significant positive correlation between seed yield and number of pods per plant. Seeds per pod were positively correlated with seed yield at genotypic level. Negative correlation was observed between seed yield and 100-seed weight. Number of pods per plant was negatively correlated with pod length and 100-seed weight.

Sarswathy *et al*., (1979) showed that number of clusters had the maximum direct positive effect on seed yield. Number of pods per plant had negative direct effect on seed yield.

Satyan *et al*., (1986) observed that 100-seed weight had maximum direct influences on seed yield followed by pod length, number of pods per plant and plant height.

Upadhyaya *et al.,* (1980) with their studies in character association in 115 varieties of green gram of different maturity groups reported that in the early maturity group, number of pods per plant, plant height and number of seeds per pod were the main yield components, whereas, in late maturity group number of pods per plant, 100-seed weight and number of branches per plant were the main yield components.

Gupta et *al*. (1982) observed higher magnitude of genotypic correlation coefficients those phenotypic correlation coefficients. The seed yield per plant was positively and significantly correlated with number of clusters per plant, number of pods per plant, number of seeds per pod and days to maturity.

Kumani and George (1982) reported that seed yield of mung bean showed strong positive correlation with number of nodes per plant, number of pods per plant, plant height, seeds per pod, pod length, 100-seed weight and clusters per plant.

Deore (1983) observed that number of pods per plant, pod length, 100seed weight and harvest index had significant positive association with seed yield, while negative correlation was observed between days to 50 % floweringand plant height.

Malik *et al.,* (1987) reported negative correlation of seed yield with days to maturity, pod length and grain weight. He also investigated maximum relative selection efficiency for branches per plant in mung bean. In mungbean, positive correlation of yield with yield components was observed (Tomaret al., 1973: Khalid et al., 1984).

Thandapani and Rao (1984) studied that yield parameters and their significance in 15 green gram genotypes in relation to seed yield and observed that clusters per plant had the greatest direct effect on seed yield, while pod length and seed weight were also directly associated with it.

Ramana and Singh (1987) studied the character associations in 37 promising varieties and two checks of green gram grown in spring and rainy season and found that in both the seasons, seed yield per plant showed significant correlations with plant height, pods per plant, clusters per plant and seeds per pod. Phenotypic correlations were smaller than the genotypic correlations in both the seasons.

Natarajan *et al*. (1988) while studying genetic association among 45 genotypes of green gram showed that seed yield was significantly and positively correlated with plant height, clusters per plant and pods per plant andseeds per pod.

Raut *et al*., (1988) observed that genotypic correlation coefficients were higher than the phenotypic correlation coefficients. They further reported positive correlation of seed yield with number of seeds per pod, number of branches per plant, clusters per plant and pods per plant at genotypic level. Number of pods per plant exhibited negative and non-significant association with seed yield. The high positive contribution to seed yield per plant was recorded by number of clusters per plant, 100-seed weight and seeds per pod.

Patil and Narkhede (1987) showed positive correlation of seed yield with plant height, days to maturity, number of pod per plant, seeds per pod and 100-seed weight.

Lakshmaiah *et al.,* (1989) and Satyan et al., (1989) showed that seed yield per plant had significant positive correlation with clusters per plant, plant height, number of pods per plant, days to flowering and days to maturity. They concluded that for improving the yield of green gram, emphasis should be given on clusters per plant and pods per plant during selection. Similar conclusions were reported by Pokle and Nomulwar (1978).

Borah and Hazarika (1995) observed that, seed yield per plant wasassociated significantly with almost all yield attributing characters indicating that selection for these characters will help in identifying high yielding varieties of green gram.

Khattak *et al.,* (1995) studied 10 mung bean genotypes in RCBD with three replications. Their results reported that seed yield per plant showed positive and significant correlation with 100-seed weight. Branches per plant recorded negative and significant correlation with seed yield. In contrast, clusters per plant recorded no association with seed yield.

Ghafoor *et al*., (2000) observed cluster analysis for nine quantitative traits in mung bean. They observed significant negative correlation of days to maturity with all the characters except branches per plant and suggested that short to medium maturity mung bean cultivars were to be selected for high yield. They identified 44 pure lines on the basis of important agronomic traits that were recommended for testing under a wide range of agro-ecologicalcondition in pursuit of best mung bean cultivars.

Gill *et al.*, (2000) reported that, pods per plant and 100-seed weightwere important yield components and seed yield per plant had a significant positive correlation with pods per plant, seeds per pod and 100-seed weight.

Kapoor *et al.,* (2000) observed that number of seeds per pod and 100seed weight were the main contributing characters towards the seed yield and pod length contributed indirectly towards seed yield via the number of seeds per pod and 100-seed weight.

Venkateshwarlu (2001b) found that pods per plant, days to maturity, plant height, 100-seed weight, seeds per pod and pod length showed significantand positive association with seed yield.

Khan *et al.,* (2001) evaluated 15 divergent genotypes for correlation studies. The results showed that seed yield was positively and significantly correlated with number of branches, pods per plant and total biomass per plant. A non-significant positive association of seed yield was observed with days to 50% flowering, days to maturity and pod length. Number of branches, number of pods and total dry biomass were found best among the yield components in mung bean.

Dixit *et al.,* (2002) revealed significant positive correlation of seed yield with pods per plant, biological yield, harvest index and 100-seed weight.

Haritha and Reddy Sekhar (2002) evaluated 50 genotypes of mung bean and reported that high significant positive correlation of grain yield with harvest index, biological yield per plant, pods per plant and pods per cluster. Harvest index and biological yield per plant found high positive significant association with pods per plant, clusters per plant and pods per cluster. They also found the association of grain yield with harvest index, followed by biological yield per plant and pods per plant at both phenotypic and genotypic levels.

Kumar *et al*., (2002) observed highest correlation between number of pods per plant and grain yield and they noticed that the correlation coefficient between number of branches per plant and grain yield was positive. The correlation coefficient between 100-grain weight and number of grains per pod with grain yield was observed to be high.

Pandey and Singh (2002) found positive association of seed yield with seeds per pod but negative with days to maturity. Days to flowering and daysto maturity were positively correlated with each other and with plant height.

Saifullah and Mahmood (2002) evaluated 20 mung bean genotypes in RBD and reported that seed yield was positively and significantly correlated with harvest index, biological yield, number of seeds per pod and number of pods per plant. Plant height had positive and significant correlation with number of branches and biological yield. Days to flowering was positively and significantly correlated with biological yield. Number of pods per plant had highly significant positive correlation with biological yield per plant and harvest index. In two separate studies positive association of pods per plant and grains per pod with grain yield in mung bean genotypes of diverse origin were observed (Ajmal and Hassan, 2002; Aslam et al., 2002).

Madrap *et al*. (2003) observed that seed yield was positively and significantly correlated with days to maturity, numbers of secondary branches per plant, number of pods per plant and 100-seed weight.

Reddy *et al., (*2003) reported that seed yield per plant was significantly and positively correlated with plant height and number of clusters per plant at both genotypic and phenotypic levels.

Singh (2003) reported that grain yield per plant was positively and significantly correlated with pods per plant and plant height.

Kumar *et al*., (2004) evaluated 21 diverse mung bean genotypes along with four checks in RBD. They reported that seed yield per plant had significant and positive association with days to maturity, plant height, primary branches per plant, secondary branches per plant, pods per cluster, pods per plant and harvest index at both phenotypic and genotypic levels.

Maddewad (2005) reported significant positive correlation of seed yield with number of seeds per pod, pod length and 100-seed weight.

Ahmad *et al.,* (2015) evaluated 84 genotypes and found that seed yield per plant possessed highly significant positive correlation with days to flowering, days to maturity, plant height, number of pods per plant and numberof clusters per plant.

Gupta *et al*., (2005) reported that seed yield had positive and highly significant association with pods per plant, biological yield per plant, harvest index and indicated that pods per plant, biological yield and harvest index had maximum direct contribution.

Rao *et al.* (2006) studied in 60 mung bean genotypes. Genotypic correlation revealed that seed yield had positive and highly significant association with pods per plant, biological yield per plant and harvest index.

Sirohi and Kumar (2006) studied 19 diverse genotypes of mung bean. They found genotypic correlation more than phenotypic ones. Number of clusters per plant and number of productive pods per plant exhibited significantand positive correlation with seed yield per plant. Correlation coefficients revealed that at phenotypic level, only two traits i.e. number of clusters per plant and number of productive pods per plant showed significant positive correlation with seed yield per plant. At the genotypic level none of the traits observed a significant positive correlation among themselves as well as with seed yield per plant.

Parameshwarappa and Salimath (2007) reported that pods per plant, number of branches per plant and plant height were significantly and positively associated with seed yield per plant.

Saeed *et al*., (2007) revealed that in mung bean, seed yield per plant showed a positive and significant association with pod bearing branches per plant and pod clusters per plant. They concluded that the greater number of pod clusters per plant could be used for relatively better selection criterion.

Iqbal *et al.* (2007) conducted an experiment using 43 mung bean genotypes for the study of association of seed yield per plant pod bearing branches per plant, pod clusters per plant pod clusters on branches and reported that seed yield was positively and significantly associated with pod bearing branches per plant, pod clusters per plant and pod clusters on branches.

Kaveri *et al.,* (2007) evaluated 116 germplasm lines of mung bean inRBD with two replications. Their findings revealed that grain yield wassignificantly and positively correlated with number of clusters per plant,number of pods per cluster, pod length, seeds per pod and 100 seed weight. Days to 50% flowering showed significant negative correlation with seed yield. Pandey et al., (2007) evaluated 20 mung bean genotypes in RBD and revealed that harvest index had highest significant correlation with seed yield at both phenotypic and genotypic levels. At genotypic level, pod number, 100seed weight and pod length had significant positive association with seed yield, besides harvest index. At phenotypic level significant and positive correlation was observed between plant height, seed number, pod length and seed number.

Wani *et al.,* (2007) evaluated 20 genotypes to study the association among qualitative and quantitative characters. They observed positive and significant correlation of seed yield with number of pods per plant followed by plant height, number of pods per cluster and pod length.

Correlations among plant height, days to 50% flowering, days to maturity, seed yield per plant, 100-seed weight, harvest index and seed yield per hectare were worked out by Gul et al., (2008). They observed that seedyield per plot was found to be non-significantly correlated with 100-seed weight. Harvest index had significant positive correlation with seed yield per plant. They also found that, seed yield per plant was positively correlated with pods per plant, seed yield per hectare and harvest index.

Hakim (2008) studied 350 mung bean genotypes in RBD with three replication. He reported that number of pods per plant, plant height, days to flowering and days to maturity were positively and significantly correlated with seed yield. In contrast, seed size was significantly and negatively correlated with seed yield.

Rozina *et al.,* (2008) conducted an experiment with 26 mung bean genotypes and reported that, seed yield was significantly and positively correlated with pods per plant and harvest index. Plant height was significantly and positively correlated with days to maturity, seeds per pod and dry weight per plot, while it was negatively correlated with 100-seed weight and harvest index. Days to 50% flowering was positively associated with days to maturity, number of pods per plant, plant height and dry weight, while it was negatively associated with number of seeds per pod, seed yield per plant, 100-seed weight and harvest index.

Arshad *et al.,* (2009) observed that plant height among the characters exhibited positive and significant association with seed yield per plant at both phenotypic and genotypic levels. In addition, positive and significant correlation of plant height with days to flowering and secondary branches per plant was also observed.

Tejbir *et al.,* (2009) conducted correlation study in 40 mung bean genotypes in RBD with three replications in four different environments. They reported that the seed yield showed positive and significant association with number of seeds per pod, 100 seed weight, biological yield and harvest index atphenotypic level in all the environments. Days to 50% flowering recorded significant and positive correlation with plant height and biological yield in two out of the four environments. In contrast number of pods per clustershowed negative correlation with days to maturity.

Positive correlation between plant height, primary branches per plant, pods per plant and pods per cluster were reported by Dadepeer et al., (2009). Significant and positive correlation with seed yield was observed for 50% flowering, harvest index, pods per plant at both phenotypic and genotypic level.

Singh *et al.,* (2009) conducted experiment to estimate the correlation coefficients among 12 quantitative characters in 80 mung bean germplasmlines in three environments. Positive association at phenotypic and genotypic level was also recorded between pods per cluster and seeds per pod and between pods per plant and harvest index.

Rahim *et al.,* (2010) studied 26 mung bean genotypes. They reported positive correlation between days to 50% flowering and days to 80% maturity. Days to 50% flowering was positively associated with plant height and numberof seeds per pod and negatively correlated with 100-seed weight. Days to 80% maturity showed strong positive correlation with pod length. Number of pods per plant showed positive relation with pod length, number of seeds per pod and grain yield.

Vinay *et al.,* (2010) studied character association in 23 mung bean genotypes for different quantitative characters and recorded high significant correlation for pods per plant and harvest index at both phenotypic and genotypic levels with seed yield per plant. In contrast, days to maturity and plant height were negatively correlated with seed yield per plant at both phenotypic and genotypic levels.

Huda *et al.,* (2010) observed that seed yield had a significant positive association with pod number and seed size. But, seed size was found to maintain a negative association with seed number, so good seed size appeared to be strong contributors of the seed yield of mung bean.

Kumar *et al*., (2010) studied character association in 23 genotypes of mung bean. They recorded high significant correlation for pods per plant and harvest index at both genotypic and phenotypic levels with seed yield per plant.

Khajudparn and Tantasawat (2011) studied 56 mung bean accessions and 14 characters. They showed that seed yield was significantly and positively correlated with pods per plant, clusters per plant, seeds per pod, seeds per plant, biomass and branches per plant and negatively correlated with 100-seed weight, plant height, pod length and days to maturity.

Reddy *et al.,* (2011) conducted correlation analysis in 35 divergent genotypes of green gram and observed positive and significant association of seed yield per plant with days to maturity, plant height, number of pods per plant, number of seeds per pod and 100-seed weight.

Srivastava and Singh (2012) revealed that seed yield had positive and significant correlation with number of pods per plant, 100-seed weight, days to maturity and number of pods per cluster.

Zaid *et al.,* (2012) evaluated 20 mung bean genotypes for correlation among different yield contributing traits i.e., plant height, pods per plant, pod length, seeds per pod, biological yield, and grain yield. Genotypic correlation analysis showed characters like plant height, pods per plant, pod length on seed yield at phenotypic level. They concluded that, grain yield and seeds per pod could be the best criteria in any breeding program for increasing yield in mung bean genotypes.

Khanpara *et al.* (2012) studied correlation coefficients among 12 yield contributing traits using 58 genotypes of green gram. The seed yield per plant showed highly significant and positive correlations both at genotypic and phenotypic levels with number of pods per plant, number of pods per cluster, number of clusters per plant and number of seeds per pod. Seed yield per plant showed negative and highly significant correlation with days to maturity at both the levels and days to 50 per cent flowering at only genotypic level.

Nand and Anuradha (2013) reported a positive and significant correlation with seed yield by traits like days to 50% flowering, number of branches per plant, number of pods per plant, days to maturity and 100-need weight.

Narasimhulu *et al.,* (2013) revealed that seed yield had positive and significant correlation with number of pads per plant, clusters per plant, number of pods per cluster and biological yield per plant. Non-significant associations between seed yield and 100-seed weight. Number of clusters per plant was significantly and positively associated with branches per plant, pods per plant and pods per cluster. Negative associations were found between clusters per plant and 100 seed weight. Significantly negative correlation was found between pods per plant and 100 seed weight.

Kumar *et al.,* (2013) found number of secondary branches per plant, number of branches per plant, number of pods per plant, number of grains per pod, pod length and 100-seed weight had shown positive and significant correlation along with their high positive direct effect with grain yield.

Kumar et al., (2013) revealed that number of secondary branches per plant, number of clusters per plant, number of pods per plant, number of grains per pod, pod length and 100-seed weight had shown positive and significant correlation along with their high positive direct effect with grain yield.

Gadakh *et al.,* (2013) evaluated 50 diverse genotypes of mung bean for 15 quantitative characters for the correlation coefficient. Character association indicated that harvest index and 100-seed weight had significant positive correlation with seed yield.

Lavanya *et al.,* (2014) studied correlation in some mung bean genotypes for quantitative traits. The correlation of yield and yield contributing charactersindicated that seed yield per plant was positive and significantly associated with days to maturity, plant height, number of pods per plant, number of seeds per pod and 100-seed weight.

Singh and Kumar (2014) evaluated 58 diverse genotypes with 12 traits. They observed that seed yield per plant had highly significant and positive correlations both at genotypic and phenotypic levels with number of pods per plant, number of pods per cluster, number of cluster per plant and number of seeds per pod. Days to maturity showed negative and highly significant correlation with seed yield per plant at phenotypic and genotypic levels and days to 50% flowering at only genotypic level. The seed yield per plant did not show any significant association with protein content and other traits including number of branches per plant, number of pods per cluster and 100-seed weight that showed positive and significant correlation to protein content.

Canci and Toker (2014) carried out a study to evaluate the yield components in mung bean. They observed that the grain weight was strongly correlated with pod length and pod width. Pods per plant were significantly andpositively associated with branches per plant. The seed yield was highly associated with biological and straw yields.

Ahmad *et al.* (2015) evaluated 35 genotypes of mung bean along with check Shalimar Mung bean-1. Seed yield per plant showed positive significant association with number of clusters per plant, number of primary branches per plant, number of pods per plant, number of seeds per pod, pod length and 100seed weight.

Baisakh *et al.,* (2015) estimated character association in mutant lines of green gram for yield attributes. Plant height, cluster per plant, pods per plant, pod length and seeds per pod showed significant positive correlation withyield.

Naeem *et al.,* (2015) were evaluated 10 mung bean genotypes for seed yield and yield related traits. Correlation among different morphological and economic traits and their direct and indirect effects were estimated. They showed characters like, primary branches per plant, pods per plant and days to 50 % flowering have positive association with seed yield per plant at both genotypic and phenotypic levels. They also observed plant height and seeds perpod had positive correlation with seed yield per plant at phenotypic and genotypic level, respectively.

Das and Barua (2015) studied 23 genotypes of green gram. Result showed that seeds per pod, 100-seed weight, pods per plant, pod filling percentage and pod length showed significant positive correlations with seed yield per plant both at phenotypic and genotypic levels.

Dhoot *et al*., (2017) studied correlation among quantitative traits and their direct and indirect effect on seed yield in F_2 populations of mung bean. Correlation analysis revealed that seed yield was significantly and positively correlated with pods per plants and harvest index in F_2 population of Mcha x Pusa Vishal and with plant height, primary branches per plant, clusters per plant, pods per plant, straw yield per plant and harvest index in F_2 populationof Mcha x GM-4.

Kritika and Yadav (2017) studied 70 mung bean RILS (F. generation), made from a cross between ML-776 and MH 2-15. They found that seed yield had positive significant correlation with plant height, number of branches per plant, number of pods per plant, number of seeds per pod, 100-seed weight, biological yield and harvest index and negatively with days to flowering, days to maturity and reaction to MYMV.

Ghimire *et al.* (2017) were conducted an experiment for correlation and path studies in seven genotypes of mung bean. Results showed that seed yield was positive and significantly correlated with primary branches, secondary branches, biological yield and grain weight. Biological yield, pod length, days to 50% flowering and number of grains per pod contributed maximum positive and direct effect on seed yield.

Parihar *et al.,* (2018) studied the inter-relationship among various quantitative characters in 80 mung bean genotypes. They revealed that days to 50% flowering has positive significant correlation with days to maturity, plant height and pods per plant. Pods per plant have positive significant correlation with plant height, secondary branches per plant and days to maturity. Plant height has positive significant correlation with days to maturity and secondary branches per plant.

Divya Ramakrishnan *et al*., (2018) studied 20 yield and yield related parameters in 374 diverse genotypes of mung bean. Association analysis indicated that, seed yield per plant showed significant positive correlation with pod yield per plant followed by number of pods per plant, number of clusters per plant and shelling percentage.

CHAPTER -III

MATERIAL AND METHODS

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled "**Effect of alpha amylase on seed germination in mungbean**" has been undertaken at Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

PROGRAMME OF RESEARCH WORK

1) Experimental material

The experimental material included in the present study comprised of 12 genotypes including checks. These all genotypes and standard checks will be grown in Randomized Block Design in *Kharif* ,2021. Genotypes and Checks involved in the present investigation are presented in Table 1.

2) Experimental Details:

Complete set of 12 entries will be evaluated during *Kharif,* 2021 at Department of Agricultural Botany, College of Agriculture, VNMKV, Parbhani.

1	Experiment design	:	Randomized Block Design.
2	No. of replications	:	Three
3	No. of genotypes	:	12
4	Spacing (cm)	:	45 X 10
5	No of rows per plot	:	04
6	Plot size	:	0.90 X 4.5 m^2
7	Fertilizer dose	:	25: 50: 00 Kg N: P: K kg/ha

All the agronomical practices and plant protection measures will be followed as and when required to raise a good crop of Mung Bean.

Table 1: Experimental Material Used in the Study.

Treatment details : Genotypes- 12

Sr. no	Genotypes	Source
1.	BM 2019-1	VNMKV, Parbhani
2.	BM-4(CH)	VNMKV, Parbhani
3.	BPMR 145 (CH)	VNMKV, Parbhani
4.	BM 2003-2 (CH)	VNMKV, Parbhani
5.	AKM-12-14	Dr.PDKV,Akola
6.	AKM-12-23	Dr.PDKV,Akola
7.	AKM-12-24	Dr.PDKV,Akola
8.	AKM-12-28	Dr.PDKV,Akola
9.	Vaibhav (CH)	MPKV,Rahuri
10.	Vishal	MPKV,Rahuri
11.	Utkarsha (CH)	MPKV,Rahuri
12.	Phule M 707-5	MPKV,Rahuri

3) Observations to be recorded:

Five random competitive plants excluding border ones will be selected from each plot in each replication to record observations. The Twenty characters were recorded in the field and laboratory and the mean values were subjected for statistical analysis. The data on following yield, yield components and seed quality characters were recorded.

A) Morphological characters:

1. Days to 50 per cent flowering

The number of days taken from sowing to the opening of flowers in 50 percent ofplant in each plot was recorded.

2. Days to maturity

The total number of days taken from date of sowing to complete maturity was taken as days to maturity.

3. Plant height (cm)

The height of the fully matured plant from the base of the plant to the tip of the inflorescence.

4. Days required for shattering

Number of days taken from the date of maturity to the shattering of pods.

B) Yield contributing characters

5. Number of Primary Branches per plant

Total number of branches arising from the main stem at harvest was recorded.

6. No. of Pods per cluster

The number of pods in individual cluster were counted from the selected plants and mean was calculated.

7. Number of Pods per plant

The total number of seeds bearing pods in the selected plants was counted at maturity.The mean was calculated.

8. Length of Pod (cm)

Ten randomly selected pods from each of the selected plants were taken and the length was measured in centimetre.

9. No. of Seeds per Pod

The randomly selected pods from each of the selected plants were taken and the number of seeds per pod was counted.

10. 100 Seed Weight (gm)

The weight of 100-seeds drawn at random was recorded and expressed in gram.

11. Seed yield per plant (gm)

Total weight of seed from the selected plants was recorded and expressed on per plant basis in gram.

12. Harvest index (%)

Economic yield was the seeds obtained from ten observational plants. The plants were dried and weighted to constitute biological yield. The biological yield (total dry matter after harvesting and sun drying) and seed or grain yield of each plant was recorded in grams and the harvest index was calculated as follows: Grain yield (gm) Harvest index (%)

C) Seed quality and Biochemical characters:

13. Germination percentage (%)

Germination percentage was recorded by using rolled towel paper method. The 100 seeds were placed in four replications on moist towel paper, rolled properly and kept inseed germinator at constant temperature (25^{o}C) and relative humidity (80 %). Final germination recorded on 8th day and germination expressed in percentage. (ISTA, 1999).

14. Root and Shoot Length (cm)

15. Vigour Index I (%)

Seedling vigour index-I was calculated as per formula given by ISTA (1976)SVI-I = Germination percentage (%) x Mean seedling length (cm)

16. Seed Hardness (kg/ cm^2) : Seed hardness is measured by instrument seed hardener

17. Seedling dry weight (g)

18. Vigour Index - II

19. Pod opening time (hrs)

20. Alpha Amylase %

The enzyme activity *viz.,* α-amylase and dehydrogenase were studied.

Plate 3.1. Germination of seed

Plate 3.2. Root and Shoot length (cm)

The α-amylase enzyme activity was assayed as per the procedure given by Bernfed (1955).

Reagents:

1. 95% Ethanol
2. Distilled water
3. 1 N NaOH
4. 100 ml volumetric flask
5. 1 N Acetic acid
6. Water bath Iodine-Potassium iodide solution
7. Spectrophotometer
8. Standard amylase

Composition of reaction mixtures: A)1 N NaOH solution:

Dissolve 40 g of NaOH in 1000 ml distilled water. B) 1 N Acetic acid solution:

Dilute 57.5 ml glacial acetic acid to 1000 ml using distilled water. C) Iodine- Potassium iodide solution:

Dissolve 0.26 g of iodine in 10 ml of potassium iodide solution containing 2.6 g of KI.

D) Standard amylase solution:

Take 40 mg of pure potato starch (amylase) in a 100 ml volumetric flask and add 1 ml of 95% ethanol and 9.0 ml of 1 N NaOH. Shake well and boil over water bath for 10 minutes and make up the solution to 100 ml using distilled water.

Procedure:

1. Weigh 100 mg well powdered milled Mung bean in to 100 ml volumetric flask. (In this experiment one gram powder is used)

2. Add 1 ml 95% ethanol and 9 ml of 1 N NaOH.

3. Heat the sample for 10 minutes in boiling water bath, cool it and make up thevolume to 100 ml by adding distilled water.

4. Pippete out 5 ml from the 100 ml solution into another 100 ml volumetric flask.

5. Add 1 ml 1 N acetic acid and then 2 ml iodide solution and make the volume to 100ml.

6. Shake, stand for 20 minutes and determine the percent Transmittance at 620 nmusing a colorimeter.

7. Prepare a series of standard starch solution containing 0, 20, 40, 60, 80 and 100 %amylase as in the steps 1 to 5.

8. Read the transmittance of the standards at 620 nm and plot a standard graph.

9. Amylase content of the sample was determined in reference to the standard curveand expressed on percent basis.

Making of amylase standards:

1. Pipette out 1, 2, 3, 4, and 5 ml of the standard amylase into 100 ml volumetric flasks in three replications.

2. Keep one flask as blank without adding anything.

3. Add 1 ml 1 N acetic acid and 2 ml I-KI solution to all the flasks including blank.

4. Make up all the flasks to 100 ml using distilled water and cover all the flasks with a black cloth or aluminium foil to prevent direct light exposure as I-KI disintegrates on exposure to light.

5. Keep for 20 minutes and take reading at 620 nm in a spectrophotometer.

6. The standards including blank, correspond to 0%, 4%, 8%, 12%, 16% and 20% of amylase.

Plate 3.3. Alpha amylase activity

Plate 3.4. Seed hardness

7. Draw a standard curve using the absorbance reading.

A calibration curve was established with standard maltose (0.2 to 2.0 ml. of distilled water) and used to convert the colorimeter reading into mg of maltose. The activity was expressed as up of maltose liberated mg_{-1} of protein.

Calculation

One unit of α–amylase is expressed as mg of maltose released per min. per gm. of sample (mg/gm).

3.3 Statistical analysis:

The statistical analysis of data was carried out as per the standard method suggested by Panse and Sukhatme (1989).

CHAPTER -IV

RESULTS AND DISCUSSION

CHAPTER - IV

RESULTS AND DISCUSSION

Yield is a complex character that is influenced by many different factors. As a result, knowledge of the extent of association between yield and yield contributing characters is required. The expression of various traits is frequently affected by breeding materials and environments. As a result, information on character association between traits and yield for the specific breeding material being used at a specific location is critical for breeding high yielding genotypes. The amount of genetic variability in a population determines the success of any breeding programme. A greater range of genetic variability aids in the selection of desired genotypes.

Seed dormancy is an important feature of mungbean. Because rai frequently occur during harvest, non-dormant cultivars frequently germinate in- situ on the standing crop. The significance of seed dormancy lies in the seed's ability to overcome unfavourable condition and remain viable until the of a favourable environment. Seed dormancy occurs when seeds fail to germinate despite favourable moisture, temperature, and oxygen conditio (Wareing, 1963).

The first prerequisite for the success of breeding programmes is to pool genotypes from diverse eco-geographical region and further study the extent of genetic diversity, for yield, yield attributes, and innovative traits like seed dormancy for meaningful utilisation of donors in breeding programmes. Most of the characters in a plant's integrated structure are interconnected. As a result, direct selection-based yield alone is ineffective, and it has been suggested thatit would be more meaningful to probe the structure of yield through its components rather than directly.

Knowledge of genetic variability and the relatiohip between various quantitative characters is useful in determining selection criteria to bring out potential improvements. Only when compared to non-genetic variation cangenetic variation of important traits be used for crop improvement. Several studies in mungbean by various researchers revealed wide variation for various agronomic traits. Yield is a complex genetically controlled trait that is determined by a number of component traits that are also quantitatively inherited.

The present investigation was undertaken with assess the Dormancy in Mungbean, the entitled “Effect of Alpha Amylase on Seed Germination in Mungbean (*Vigna radiata* L.)”. The observation of yield contributing characters i.e. days to 50% flowering, days to maturity, plant height (cm), days to shattering, No. of primary branches, No. of pods/cluster, No. of pods/plant, length of lods (cm), No. of seeds/ pod, 100 seed weight, harvest index and seed yield/plant (g) were taken at field whereas, seed quality parameters *viz.,* germination percentage, seedling length (cm), seedling dry wt.(g), vigour index-I (%), vigour index-II (%) and biochemical parameters *viz.,* α-amylase activity were completed in laboratories of Seed Technology, Department of Agricultural Botany and Agri. Chemistry and Soil Science, Department of Agricultural Chemistry and Soil Science, VNMKV, Parbhani and results are presented under following subheadings.

4.1 Analysis of variance

The mean values of observation recorded were subjected to analysis of variances for randomized block design in individual season and pooled (Table 4.1) revealed that mean squares due to genotypes found significant for all the characters in all environments over a pooled analysis.

The variation due to genotypes were significant for all the characters under study both at 5% and 1% probability levels in both season. The significant differences in characters indicate the presence of variability in experimental material.

Table 4.1: Analysis of variance for randomized block design for different characters in mungbean genotypes

Source of Variation	df	Days to 50% Flowering	Days to Maturity	Plant Height(cm)	Days req. For shattering	Prim. Branches per plant	No. of pods percluster	pods per plant	length of pod (cm)	No. of seeds perpod	100 seed weight (g)
Replication	**2**	1.69	4.69	30.27	12.30	0.19	0.17	0.27	3.17	0.19	0.05
Genotypes	**11**	3.90**	8.95**	470.05**	6.90**	2.86**	1.63**	161.38**	11.26**	11.93**	1.33**
Error	**22**	0.19	0.11	1.76	2.46	0.20	0.03	2.21	0.05	0.38	0.00

Source of Variation	df	Harvest Index (%)	Germination (%)	Root and Shoot Length (cm)	Vigor Index I(%)	Alpha amylase (mg/g)	Seed Hardness (Kg/cm^2)	Seedling dry wt (g)	Vigor Index II	Pod Opening time (hrs)	Seed yield perplant (g)
Replication	**2**	8.42	14.78	2.39	37386.00	6.62	0.03	0.01	30.56	10.09	4.92
Genotypes	**11**	111.83**	50.33**	10.70**	209501.00**	102.15**	0.60**	0.02**	335.28**	1371.06**	32.25**
Error	**22**	1.45	2.02	0.33	3022.00	1.07	0.00	0.00	7.98	2.15	0.05

*,**- Significant at 5 per cent and 1 per cent level, respectively

Table 4.2 : Range and Mean performance of genotypes for yield contributing, quality and biochemical traits in Mung bean

SN	Genotypes	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Days req. For shattering	Prim. Branches per plant	No. of pods percluster	podsper plant	length of pod (cm)	No. of seeds per pod	100 seed weight (g)
1	**Phule M 707-5**	37	66	50.7	89.7	3.7	2.9	8.5	11.1	14.5	4.0
2	**AKM 12-14**	36	67	58.5	90.0	5.0	4.9	30.4	6.4	11.6	3.5
3	**Vishal**	39	65	66.0	86.4	2.3	2.7	9.6	9.6	12.3	3.9
4	**AKM 12-24**	36	65	79.9	86.2	2.1	2.9	9.9	6.6	8.1	3.7
5	**BM 2019-1**	37	63	84.9	84.6	3.1	3.4	10.8	11.9	9.7	4.9
6	**AKM 12-28**	37	62	55.0	86.6	5.0	3.7	20.9	8.2	12.9	3.6
7	**AKM 12-23**	36	62	81.3	87.4	3.9	3.9	14.8	7.8	13.5	3.6
	Checks										
8	**Vaibhav**	39	64	59.7	86.9	3.5	3.5	7.4	8.8	12.7	3.6
9	**BPMR-145**	37	66	78.2	87.0	4.5	2.6	9.0	7.5	10.3	3.9
10	**Utkarsh**	39	63	86.7	86.6	2.5	2.2	4.6	10.6	13.8	5.0
11	**BM 2003-2**	37	62	74.5	88.5	3.7	3.8	12.5	10.6	14.7	4.9
12	**BM-4**	38	67	78.6	87.2	3.0	3.9	20.8	6.4	11.7	2.8
	Range Min	36	62	50.7	84.6	2.1	2.2	4.6	6.4	8.1	2.8
	Max	39	67	86.7	90	5	4.9	30.4	11.9	14.7	5
	GM	37	64	71.2	87.3	3.5	3.4	13.3	8.8	12.2	4.0
	SE±	0.251	0.195	0.766	0.906	0.257	0.1	0.859	0.128	0.356	0.03
	CD @ 5%	0.736	0.572	2.246	2.658	0.754	0.294	2.52	0.374	1.044	0.094
	CD @ 1%	1	0.778	3.053	3.612	1.025	0.4	3.424	0.508	1.419	0.129

Table 4.2 Contd....

SN	Genotypes	Harvest Index (%)	Germination (%)	Root and Shoot Length (cm)	Vigor Index I(%)	Alpha amylase (mg/g)	Seed Hardness (Kg/cm^2)	Seedling dry wt (g)	Vigor Index II	Pod Opening time (hrs)	Seed yieldper plant (g)
1	Phule M 707-5	27.8	83.5	35.0	2922.5	368	4.9	0.9	75.15	32.8	6.6
2	AKM 12-14	22.3	83	35.0	2905	361	4.8	0.9	74.7	36.8	11.8
3	Vishal	24.9	80.2	35.4	2839.8	272	4.7	0.9	72.18	51.8	5.0
4	AKM 12-24	23.9	90.3	36.3	3277.8	425	4.1	0.8	81.27	18.3	4.3
5	BM 2019-1	39.8	84.3	36.4	3068.5	375	4.9	0.8	75.87	30.8	3.5
6	AKM 12-28	23.0	82.4	35.2	2900	355	4.1	0.7	71.2	46.3	3.9
7	AKM 12-23	31.5	88.7	35.5	3148.8	387	3.9	0.7	79.83	20.8	6.0
	Checks										
8	Vaibhav	39.8	81.0	32.6	2640.6	470	4.6	0.9	72.9	16.3	3.2
9	BPMR-145	24.2	90.0	31.3	3280	512.3	4.7	1.0	82	11.0	4.1
10	Utkarsh	25.3	81.0	32.8	2656	479.6	4.6	0.8	78.9	16.0	5.8
11	BM 2003-2	28.5	91.0	35.5	3300	515.8	4.2	0.8	84	11.3	4.9
12	BM-4	32.3	78.7	38.3	3114	435.7	3.5	0.8	82.4	14.3	13.5
	Range Min	22.3	78.7	31.3	2640.6	272	3.5	0.7	71.2	11	3.2
	Max	39.8	91	38.3	3300	515.8	4.9	1	84	51.8	13.5
	GM	28.6	84.5	34.9	3100	413.12	4.4	0.8	7	25.56	6.1
	SE±	0.694	0.821	0.331	31.74	0.597	0.035	0.009	1.631	0.847	0.132
	CD @ 5%	2.04	2.407	0.969	93.09	1.751	0.104	0.03	4.783	2.484	0.387
	CD @ 1%	2.766	3.271	1.318	126.52	2.379	0.141	0.036	6.5	3.376	0.526

4.2 Range and Mean performance of genotypes for yield contributing, quality and biochemical traits in Mung bean

4.2.1 Days to 50% Flowering

The mean values for days to 50% flowering ranged from 36.0 days to 39.00 days with grand mean of 37 days in *kharif* 2021.

The data revealed that, the genotypes AKM-12-14, AKM-12-23 & AKM-12-24 recorded lowest days to 50% flowering (36.0 days), whereas, the genotypes Vaibhav, Vishal & Utkarsh (39.0 days) recorded late days to 50% flowering, followed by BM-4 (38.0 days). The remaning genotypes *viz;* Phule M 707-5, BM 2019-1, AKM 12-28, BPMR-145, BM 2003-2 recorded 37.0 days for 50% flowering (Table 4.2).

4.2.2 Days to Maturity

The mean values for days to maturity observed from 62.0 days to 67.0 days with grand mean of 64.0 days in *kharif* 2021.

The data revealed that, the genotypes AKM-12-28, AKM-12-23 & BM- 2003-2 recorded lowest days to maturity (62.0 days) while genotypes BM-4 and AKM-12-14 (67.0 days) recorded highest days to maturity. The remaning genotypes *viz;* BM 2019-1 & Utkarsh (63.0 days), Vaibhav (64.0 days), Vishal & AKM 12-24 (65.0 days), Phule M 707-5 & BPMR-145 (66.0 days) recorded respective days to maturity (Table 4.2).

4.2.3 Plant Height (cm)

The mean values for plant height observed from 50.7 cm to 86.7 cm with grand mean of 71.2 cm in *kharif* 2021.

The data revealed that, the genotypes Utkarsh (86.7 cm) recorded highest plant height, followed by BM 2019-1 (84.9 cm), AKM-12-23 (81.3cm), AKM 12-24 (79.9 cm), BM-4 (78.6 cm), BPMR-145 (78.2 cm), BM 2003-2 (74.5 cm), Vishal (66.0 cm), Vaibhav (59.7), AKM-12-14 (58.5 cm), AKM-12-28 (55.0 cm). However, the genotype Phule M 707-5 (50.7 cm) recorded lowest plant height (cm) (Table 4.2).

4.2.4 Days Required for Shattering

The mean values for days required for shattering observed from 84.6 days to 90.0 days with grand mean of 87.3 days in *kharif* 2021. The genotypes AKM-12-28 (90.0 days) recorded highest days required for shattering, followed by Phule M 707-5 (89.7 days), BM 2003-2 (88.5 days), AKM 12-23 (87.4 days), BM-4 (87.2 days), BPMR-145 (87.0 days), Vaibhav (86.9 days), AKM-12-28 & Utkarsh (86.6 days), Vishal (86.4 days), AKM-12-24 (86.2 days). However, the genotype BM 2019-1 (84.6 days) recorded lowest days required for shattering (Table 4.2).

4.2.5 No. of Primary Branches per Plant

The mean values for number of primary branches per plant observed from 2.1 to 5.0 with grand mean of 3.5 in *kharif* 2021. The genotypes AKM- 12-14 and AKM-12-28 (5.0) recorded highest number of primary branches per plant, followed by BPMR-145 (4.5), AKM-12-23 (3.9), Phule M 707-5 & BM 2003-2 (3.7), Vaibhav (3.5), BM 2019-1 (3.1), BM-4 (3.0), Utkarsh (2.5), Vishal (2.3). While, th genotype AKM-12-24 (2.1) recorded lowest number of primary branches per plant (Table 4.2).

4.2.6 No. of Pods per Cluster

The mean values for number of pods per cluster observed from 2.2 to 4.9 with grand mean of in *kharif* 2021 (Table 4.2). The genotype AKM-12-14 (4.9) recorded highest number of pods per cluster, followed by AKM-12-23 & BM-4 (3.9), BM 2003-2 (3.8), AKM 12-28 (3.7), Vaibhav (3.5), BM 2019-1 (3.4), Phule M 707-5 & AKM-12-24 (2.9), Vishal (2.7), BPMR-145 (2.6) whilethe genotype Utkarsh (2.2) recorded lowest number of pods per cluster (Table 4.2).

4.2.7 No. Pods per Plant

The mean values for number of pods per plant observed from 4.6 to 30.4with grand mean of 13.3 in *kharif* 2021. The genotype AKM-12-14 (30.4) recorded highest number of pods per plant, followed by AKM-12-28 (20.9), BM-4 (20.8), AKM-12-23 (14.8), BM 2003-2 (12.5), BM 2019-1 (10.8), AKM 12-24 (9.9), Vishal (9.6), BPMR-145 (9.0), Phule M 707-5 (8.5), Vaibhav (7.4), while the genotype Utkarsh (4.6) recorded lowest number of pods per plant (Table 4.2).

4.2.8 Length of Pod (cm)

The mean values for number of pods per plant ranged from 6.4 cm to 11.9 cm with grand mean of 8.8 cm in *kharif* 2021. The genotype BPMR-145 (11.9 cm) recorded highest length of pod, followed by Phule M 707-5 (11.1 cm), Utkarsh & BM 2003-2 (10.6 cm), Vishal (9.6 cm), Vaibhav (8.8 cm), AKM-12-28 (8.2 cm), AKM-12-23 (7.8 cm), BPMR-145 (7.5 cm), AKM 12-24(6.6 cm). However, the genotypes AKM-12-14 & BM-4 (6.4 cm) recorded lowest length of pod (Table 4.2).

4.2.9 No. of Seeds per Pod

The mean values for number of seeds per pod observed from 8.1 to 14.7 with grand mean of 12.2 in *kharif* 2021. The genotype BM 2003-2 (14.7) recorded highest number of seeds per pod, followed by Phule M 707-5 (14.5), Utkarsh (13.8), AKM-12-23 (13.5), AKM-12-28 (12.9), Vaibhav (12.7), Vishal (12.3), BM-4 (11.7), AKM-12-14 (11.6), BPMR-145 (10.3), BM 2019-1 (9.7).

However, the genotype AKM-12-24 (8.1) recorded lowest number of seeds per pod (Table 4.2).

4.2.10 100 Seed Weight (g)

The mean values for 100 seed weight observed from 2.8 g to 5.0 g with grand mean of 4.0 g in *kharif* 2021. The genotype Utkarsh (5.0 g) recorded highest 100 seed weight (g), followed by BM 2019-1 & BM 2003-2 (4.9 g), Phule M 707-5 (4.0 g), Vishal & BPMR-145 (3.9 g). However, the genotype BM-4 (2.8 g) recorded lowest 100 seed weight (g) (Table 4.2).

4.2.11 Harvest Index (%)

The mean values for harvest index observed from 22.3 % to 39.8 % withgrand mean of 28.6 % in *kharif* 2021. The genotypes BM 2019-1 & Vaibhav (39.8 %) recorded highest harvest index (%), followed by BM-4 (32.3 %), AKM 12-23 (31.5 %), BM-2003-2 (28.5 %), Phule M 707-5 (27.8 %), Utkarsh (25.3 %), Vishal (24.9 %), BPMR-145 (24.2 %), AKM-12-24 (23.9 %), AKM- 12-28 (23.0 %), while, the genotype AKM-12-14 (22.3 %) recorded lowest harvest index (Table 4.2).

4.2.12 Germination (%)

The mean values for germination (%) observed from 78.7 % to 91 % with grand mean of 84.5 % in *kharif* 2021. The genotype BM 2003-2 (91]recorded highest germination percent, followed by AKM-12-24 (90.30 %), BPMR-145 (90%), AKM 12-23 (88.7), BM 2019-1 (84), AKM 12-14 (83), AKM 12-28 (82.4), UTKARSH (81),VAIBHAV (81),VISHAL (80.2), while the genotype BM-4 (78.7) recorded lowestgermination percent (Table 4.2, Figure 1).

4.2.13 Root and Shoot Length (cm)

The mean values for root and shoot length ranged from 31.3 cm to 38.3 cm with grand mean of 34.9 cm in *kharif* 2021. The genotype AKM-12-23(38.3 cm) recorded highest root and shoot length (cm), followed by AKM 12- 28 (36.4 cm), Vishal (36.3 cm), AKM 12-24 & Utkarsh (35.5 cm), AKM 12-14 (35.4 cm), Vaibhav (35.2 cm), Phule M 707-5 & BM 2019-1 (35.0 cm), BM-4 (32.8 cm), BPMR-145 (32.6 cm) while, the genotype BM 2003-2 (31.3 cm) recorded lowest root and shoot length (Table 4.2).

4.2.14 Vigor Index – I

The mean values for vigor index - I ranged from 5640.6 to 3300 with grand mean of 3100 in *kharif* 2021. The genotype BM 2003-2 (3300),) recorded highest vigor index – I, followed by AKM-12-24 (3277.8), AKM 12-23 (3148.7), BPMR 145 (3100), AKM 12-28 (2900), Phule M 707-5 (2922),VISHAL (2839.8), while the genotype VAIBHAV (2640) recorded lowest vigor index – I (Table 4.2, Figure 2).

4.2.15 Alpha Amylase (mg/g)

The mean values for alpha amylase ranged from 272 mg/g to 515.8 mg/g with grand mean of 413.12 mg/g in *kharif* 2021. The genotype BM 2003-2 (515.8 mg/g) recorded highest alpha amylase content, followed by BPMR-145 (512.3 mg/g), Utkarsh (479 mg/g),BM-4 (435), AKM 12-24 (425), AKM 12-23 (387), PHULE M 707-5 (368), AKM 12-28 (355), AKM 12-14 (361),Vaibhav (354 mg/g), Vishal (79.6 mg/g), AKM 12-14 (77.4 mg/g), AKM-12-24 (74.0 mg/g), Phule M 707-5 (73.8 mg/g), BM-4 (72.8 mg/g), AKM-12-28 (70.8 mg/g), while the genotype VISHAL (272 mg/g) recorded lowest alpha amylase content (Table 4.2).

Table 4.3 Effect of alpha amaylase on germination percentage

SN	Genotypes	Alpha amylase	Germination (%)
1	**Phule M 707-5**	368	83.5
2	**AKM 12-14**	361	83
3	**Vishal**	272	80.2
4	**AKM 12-24**	425	90.3
5	**BM 2019-1**	375	84.3
6	**AKM 12-28**	355	82.4
7	**AKM 12-23**	387	88.7
	Checks		
8	**Vaibhav**	470	81.0
9	**BPMR-145**	512.3	90.0
10	**Utkarsh**	479.6	81.0
11	**BM 2003-2**	515.8	91.0
12	**BM-4**	435.7	78.7

Table 4.4 Effect of alpha amaylase on pod opening time

SN	Genotypes	Alpha amylase	Pod Openingtime (hrs)
1	**Phule M 707-5**	368	32.8
2	**AKM 12-14**	361	36.8
3	**Vishal**	272	51.8
4	**AKM 12-24**	425	18.3
5	**BM 2019-1**	375	30.8
6	**AKM 12-28**	355	46.3
7	**AKM 12-23**	387	20.8
	Checks		
8	**Vaibhav**	470	16.3
9	**BPMR-145**	512.3	11.0
10	**Utkarsh**	479.6	16.0
11	**BM 2003-2**	515.8	11.3
12	**BM-4**	435.7	14.3

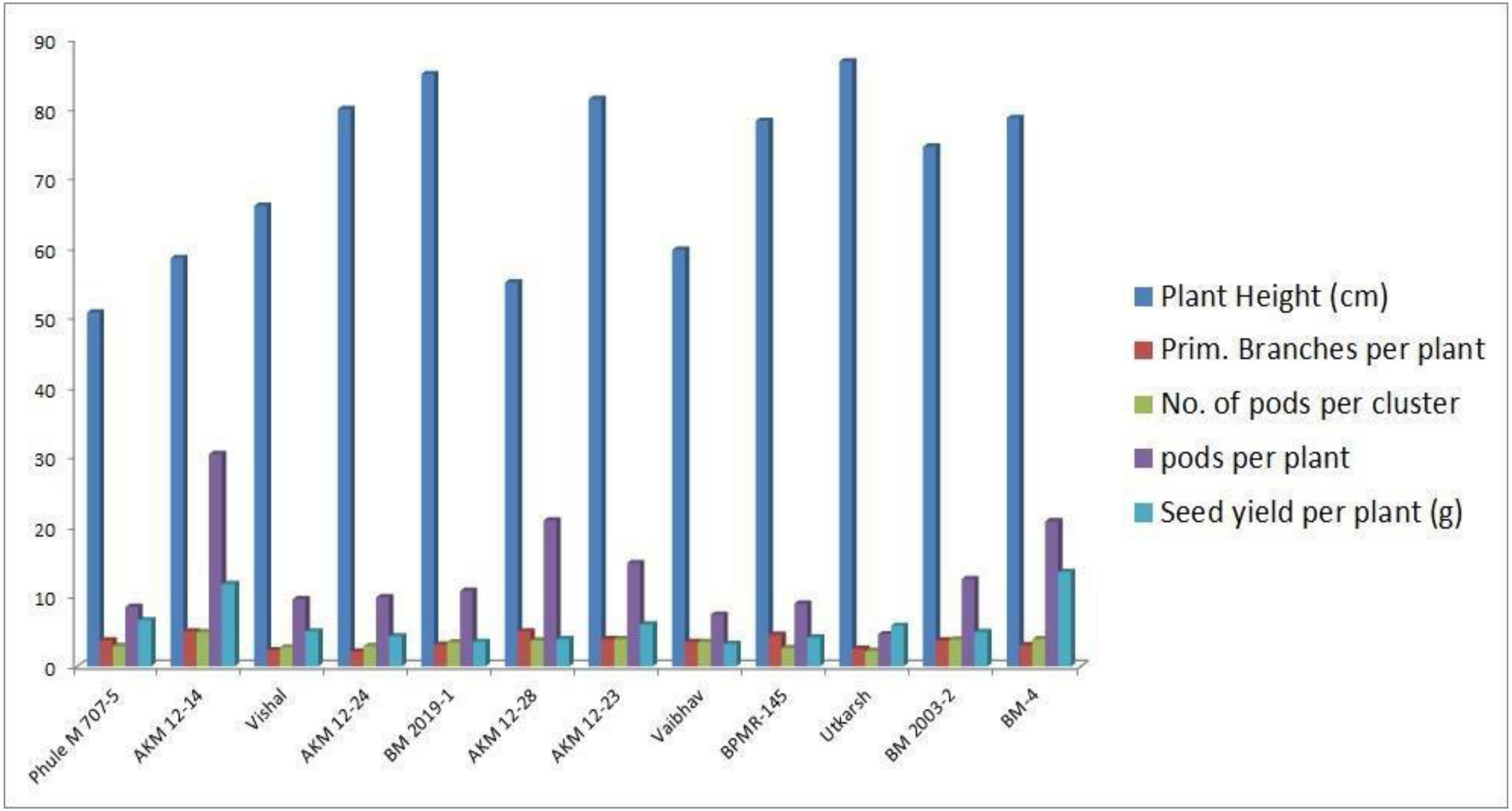

Figure 4.4: Seed Yield with its contributing characters

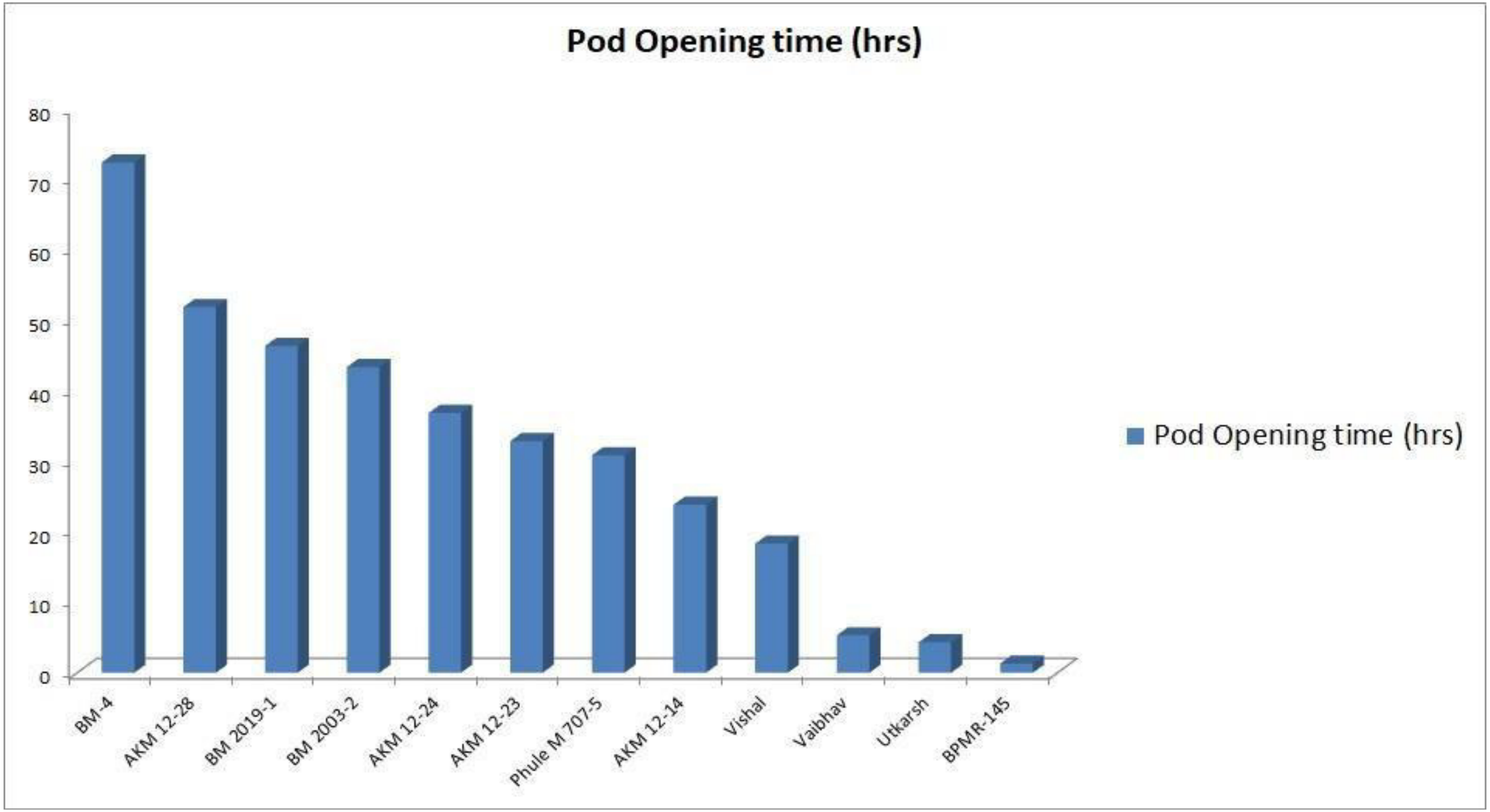

Figure 4.3: Pod Opening Time (hrs)

Table 4.5 Effect of alpha amaylase on Vigor Index I and Vigor Index II

SN	Genotypes	Alpha amylase	Vigor Index I(%)	Vigor Index II
1	**Phule M 707-5**	368	2922.5	75.15
2	**AKM 12-14**	361	2905	74.7
3	**Vishal**	272	2839.8	72.18
4	**AKM 12-24**	425	3277.8	81.27
5	**BM 2019-1**	375	3068.5	75.87
6	**AKM 12-28**	355	2900	71.2
7	**AKM 12-23**	387	3148.8	79.83
	Checks			
8	**Vaibhav**	470	2640.6	72.9
9	**BPMR-145**	512.3	3280	82
10	**Utkarsh**	479.6	2656	78.9
11	**BM 2003-2**	515.8	3300	84
12	**BM-4**	435.7	3114	82.4

4.2.16 Seed Hardness (Kg/cm^2)

The mean values for seed hardness ranged from 3.5 (kg/cm^2) to 4.9 (kg/cm^2) with grand mean of 4.4 (kg/cm^2) in *kharif* 2021. The genotypes Phule M 707-5 & AKM-12-23 (4.9 kg/cm^2) recorded highest seed hardness, followed by Utkarsh (4.8 kg/cm^2), BM-4 & Vishal (4.7 kg/cm^2), BM 2019-1 & BM 2003-2 (4.6 kg/cm^2), AKM 12-24 (4.2 kg/cm^2), AKM 12-14 & AKM 12-28 (4.1 kg/cm^2), BPMR-145 (3.9 kg/cm^2), while the genotype Vaibhav (3.5 kg/cm^2) recorded lowest seed hardness (Table 4.2).

4.2.17 Seedling Dry Weight (g)

The mean values for seedling dry weight (g) ranged from 0.7 g to 1.0 g with grand mean of 0.8 g in *kharif* 2021. The genotype BM-4 (1.0 g) recorded highest seedling dry weight (g), followed by Vishal, BM 2019-1, AKM-12-23, Utkarsh (0.9 g), Phule M 707-5, AKM-12-24, AKM-12-28, Vaibhav, BM 2003-2 (0.8 g), while the genotypes AKM 12-14 & BPMR-145 (0.7 g) recorded lowest seedling dry weight (Table 4.2).

4.2.18 Vigor Index – II

The mean values for vigor index - II ranged from 71.2 to 84.4 with grand mean of 78.78.6 in *kharif* 2021. The genotype BM 2003-2 (84) recorded highest vigor index – II, followed by BPMR 145 (82), BM 2000-2 (82), AKM 12-24 (81.27),AKM 12-23 (79.83), Utkarsh (78.9), BM 2019-1 (75.87), AKM 12-14 (74.7),Vishal (72.18), while the genotype AKM 12-28 (71.2) recorded lowest vigor index – II (Table 4.2, Figure 2).

4.2.19 Pod Opening Time (hrs)

The mean values for pod opening time ranged from 11 hrs to 51.8 hrs with grand mean of 25.56 hrs in *kharif* 2021. The genotype Vishal (51.8 hrs) recorded highest pod opening time, followed by AKM 12-28 (46.3 hrs), AKM 12-14 (36.8),Phule M 707-5 (32.8 hrs), BM2019-1 (30.8), AKM 12-23 (20.8 hrs),VAIBHAV (16.3), UTAKARSH (13),BM 2003-3-2(14.3), while the genotype BPMR-145 (11.2 hrs), recorded lowest pod opening time (Table 4.2, Figure 3).

4.2.20 Seed Yield per Plant (g)

The mean values for seed yield per plant (g) ranged from 3.2 g to 13.5 g with grand mean of 6.1 g in *kharif* 2021. The genotype Vaibhav (13.5 g) recorded highest seed yi eld per plant, followed by Utkarsh (11.8 g), AKM 12- 23 (6.6 g), BPMR-145 (6.0 g), BM 2003-2 (5.8 g), Vishal (5.0 g), AKM-12-24 (4.9 g), AKM-12-28 (4.3 g), BM-4 (4.1 g), AKM-12-14 (3.9 g), Phule M 707-5 (3.5 g), while the genotype BM 2019-1 (3.2 g) recorded lowest seed yield per plant (Table 4.2, Figure 4).

4.3 Correlation of genotypes in seed yield with yield contributing characters

Genotypic and Phenotypic Correlation was carried out & presented in Table 4.3 & Table 4.4. Correlation coefficient is an important statistical costant, which indicates the degree of association among the various characters. Seed yield is a complex character and is dependent on component characters.

Correlation measures the actual relatiohip between various plant characters and helps the plant breeder in fixing selection criteria for grain yield in parental lines and segregating population. Correlation coefficient reveals the type, nature and magnitude of association between any pair of characters. Phenotypic correlation is the association between two characters, which can be directly observed and is subjected

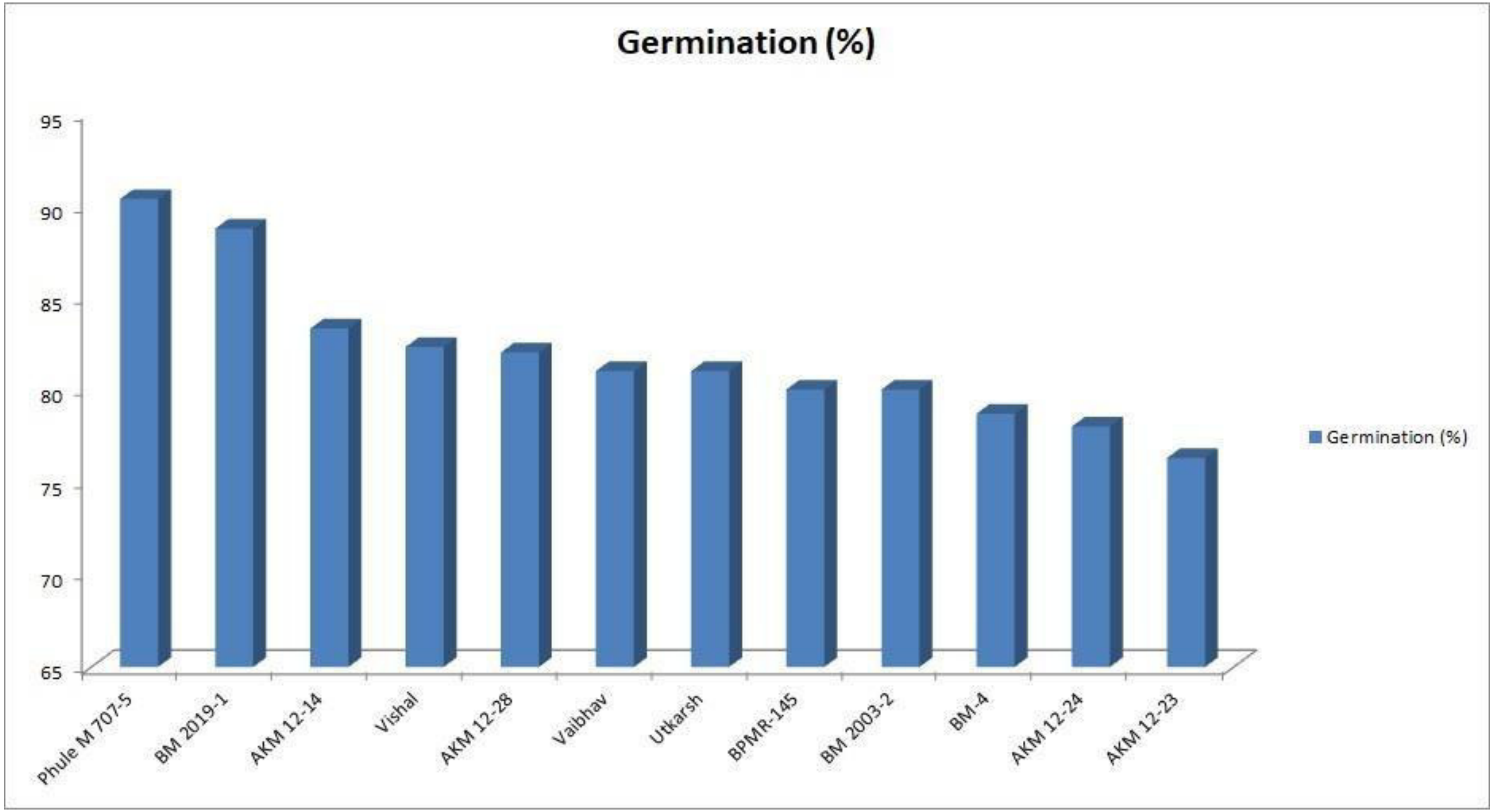

Figure 4.1: Germination Percentage

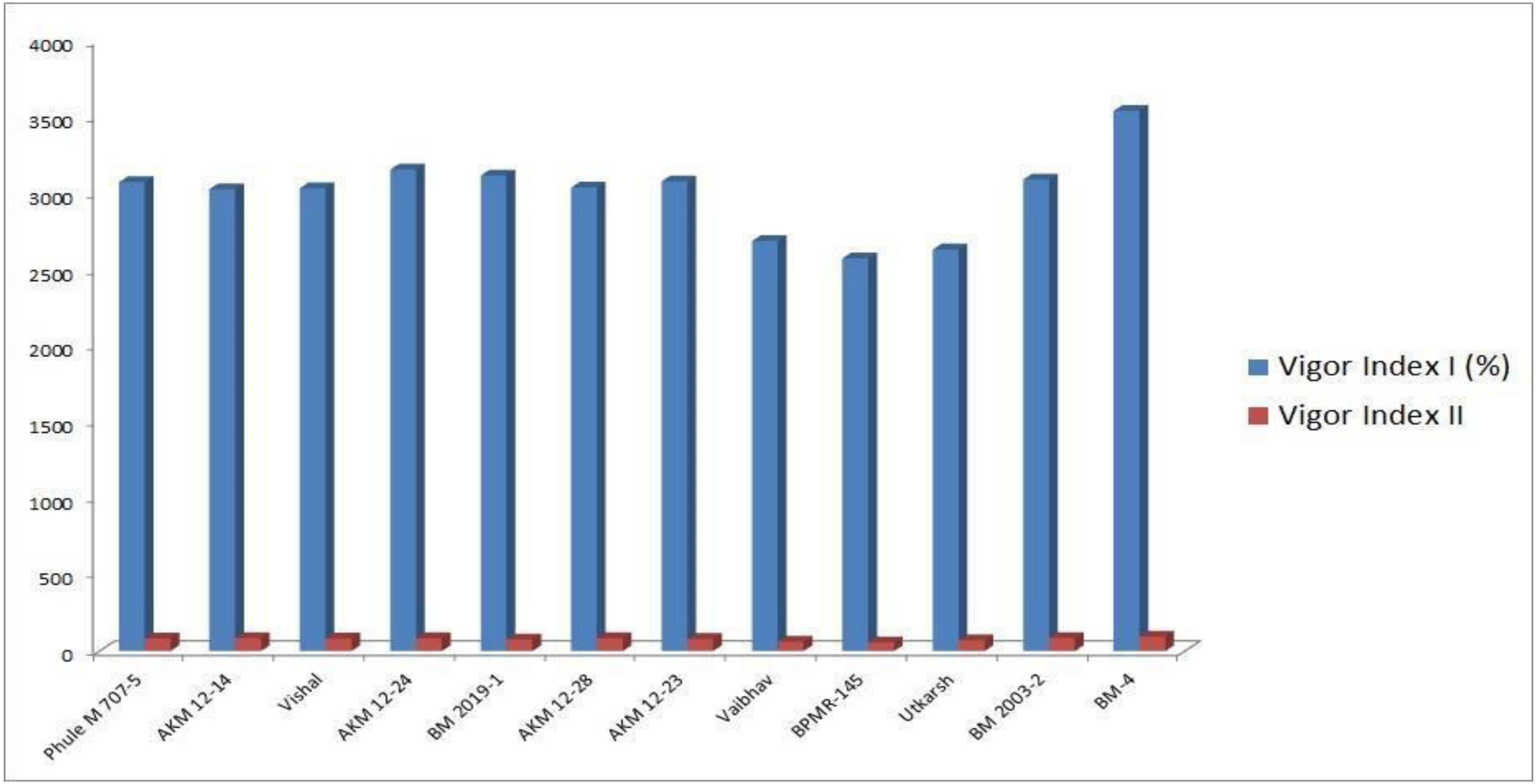

Figure 4.2: Vigor Index I and Vigor Index II

Table 4.6: Genotypic Correlation studies of genotypes on seed yield with different yield contributing characters along with quality and biochemicaltraits in Mung bean

	Days to 50% Flowering	**Days to Maturity**	**Plant Height (cm)**	**Days req. For shattering**	**Prim. Branchesper plant**	**No. of pods per cluster**	**pods per plant**	**length ofpod (cm)**	**No. of seeds per pod**	**100 seed weight (g)**
Days to 50% Flowering	**1.000**									
Days to Maturity	-0.1368	**1.000**								
Plant Height (cm)	0.061	-0.2401	**1.000**							
Days req. For shattering	-0.4692	0.5545	-0.7136 **	**1.000**						
Prim. Branches per plant	-0.5403	0.1001	-0.5048	0.7017 *	**1.000**					
No. of pods per cluster	-0.5156	0.0764	-0.2953	0.5689	0.5885 *	**1.000**				
pods per plant	-0.5679	0.2968	-0.3153	0.5297	0.6249 *	0.8749 **	**1.000**			
length of pod (cm)	0.3892	-0.4936	0.0249	-0.2137	-0.2556	-0.4136	-0.575	**1.000**		
No. of seeds per pod	0.3247	-0.3379	-0.3671	0.632 *	0.2365	0.0652	-0.0552	0.4282	**1.000**	
100 seed weight (g)	0.2443	-0.5519	0.3811	-0.3042	-0.2611	-0.4377	-0.5582	0.8119 **	0.1993	**1.000**
harvest index (%)	0.306	-0.2257	0.1951	-0.4954	-0.2082	0.1326	-0.268	0.3558	-0.0046	0.1076
Germination (%)	-0.0166	0.1185	-0.4339	0.1445	0.0973	-0.1132	-0.1029	0.6695 *	0.1176	0.325
Root and Shoot Length (cm)	-0.3063	-0.0345	0.0901	-0.0316	-0.2821	0.4342	0.4345	-0.12	-0.1295	-0.2926
Vigor Index I	-0.3626	0.0821	0.006	0.1142	-0.1735	0.4696	0.4904	-0.2055	-0.0999	-0.4079
Alpha amylase (mg/g)	0.2749	-0.3096	0.5109	-0.3415	-0.2021	-0.0826	0.0895	-0.0524	0.2263	0.118
Seed Hardness (Kg/cm^2)	0.1579	0.1715	-0.3053	0.1129	0.1115	-0.3184	-0.3129	0.5321	0.0135	0.4554
Seedling dry wt (g)	0.1287	0.6696 *	-0.3693	0.4812	0.1693	-0.1698	-0.1335	0.0188	-0.063	0.0277
Vigor Index II	-0.3598	0.0233	-0.1478	0.453	-0.115	0.4639	0.5813 *	I -0.168	0.1059	-0.3096
Pod Opening time (hrs)	-0.3542	-0.1303	0.042	-0.0644	-0.0018	0.4657	0.4914	-0.1253	-0.0703	-0.2896
Seed yield per plant (g)	-0.2077	0.6095 *	-0.0602	0.6308 *	0.690*	0.613*	0.686 *	-0.4782	0.0678	0.635*

*,**- Significant at 5 per cent and 1 per cent level, respectively

Table 4.6 Contd....

	Harvest Index (%)	Germination (%)	Root and Shoot Length (cm)	Vigor Index I	Alpha amylase(mg/g)	Seed Hardness (Kg/cm^2)	Seedling dry wt (g)	Vigor Index II	Pod Opening time (hrs)	Seed yieldper plant (g)
Days to 50% Flowering										
Days to Maturity										
Plant Height (cm)										
Days req. For shattering										
Prim. Branches per plant										
No. of pods per cluster										
pods per plant										
length of pod (cm)										
No. of seeds per pod										
100 seed weight (g)										
harvest index (%)	**1.000**									
Germination (%)	0.1813	**1.000**								
Root and Shoot Length (cm)	0.1413	0.0055	**1.000**							
Vigor Index I	0.105	-0.0116	0.9825 **	**1.000**						
Alpha amylase (mg/g)	-0.2047	0.834**	0.1166	0.536*	**1.000**					
Seed Hardness (Kg/cm^2)	0.0025	0.7371 **	-0.5664	-0.6028 *	-0.3635	**1.000**				
Seedling dry wt (g)	-0.1342	0.3297	-0.5543	-0.4655	-0.5858 *	0.6317 *	**1.000**			
Vigor Index II	-0.2032	0.032	0.9195 **	0.9198 **	0.505*	-0.5296	-0.4407	**1.000**		
Pod Opening time (hrs)	0.1457	0.0023	0.9138 **	0.9245 **	0.736**	-0.6631 *	-0.5571	0.8269 **	**1.000**	
Seed yield per plant (g)	-0.1672	-0.0937	0.4831	0.558	0.2403	-0.3608	0.013	0.5983 *	0.4035	**1.000**

*,**- Significant at 5 per cent and 1 per cent level, respectively

to changes in the environment. It measures the environmental deviation together with non-additive gene action. Genotypic correlation is the correlation of the breeding values i.e., additive and (additive xadditive) gene effects (Falconer, 1989). Therefore, study of relationship of characters with each other and with seed yield become more important in crop improvement programme. Hence, it is essential to find out relative contribution of each of the component characters in yield for giving due weightage during selection.

Genotypic Correlation

The seed yield character of the study recorded significant positive correlation with primary branches per plant (0.690), days to maturity (0.6095), days required for shattering (0.6308), number of pods per cluster (0.613), number of pods per plant (0.686), 100 seed weight (0.635) while it was non- significantly positively correlated to the number of seeds per pod (0.0678), root and shoot length (0.4831). It also reported non-significant negative correlation with days to 50% flowering (-0.2077), plant height (-0.0602), length of pod (-0.4782) and harvest index (-0.1672).

The number of primary branches might be developed into more number of pod clusters which resulted in high seed yield per plant. Such results were also revealed by Singh and Chaudhary (1977), Kumar *et al.,* (2004), Khajudparn and Tantasawat (2011), Nand and Anuradha (2013), Ahmad *et al*., (2015), Ghimire *et al*., (2017), andKritika and Yadav (2017).

The trait pods/plant showed similar results by Malhotra *et al*., (1974), Rathnaswamy *et al*., (1978), Upadhyaya *et al*., (1980), Khanpara *et al*., (2012), Das and Barua (2015) and Parihar *et al.,* (2018).

The similar results were also found by Deore, (1983), Dixit *et al*., (2002), Haritha and Reddy Sekhar, (2002), Kumar *et al*., (2004), Gupta *et al*., (2005), Gul *et al*., (2008), Vinay *et al*., (2010), Gadakh *et al*., (2013) and Dhoot *et al*., (2017). They suggested, while selecting for improvement of lines in seed yield, these characters can be keep in mind for selection.

The enzyme α-amylase showed significant positive correlation with germination percentage (0.834), time to opening of pods (0.736), vigour index I (0.536) and vigour index II (0.505). Enzyme α-amylase estimated high range of positive correlation with germination percentage, time to opening of pods, vigour index I & II (Table 4.3).

This indicates the strong association of enzyme α-amylase with germination percentage, time to opening of pods, vigour index I & II.

It means increase in enzyme activity of α-amylase with increased germination percentage, time to opening of pods, vigour index I, vigour index II and *vice-versa*.

Similar results were found by Bain and Mercer (1966), Abdul-Baki and Anderson (1972) reported amylase is respoible for embryo growth which resulted into seedling growth in germinating seeds. Dyer and Movellie (1976) also reported that increase in α-amylase activity in cereal seed results in higher germination percent. Such results were also reported by Wadhwa *et al.* (1988), Shingeshi *et al.* (1991), Desai (2004), Rahman et al., (2009), Mohankumar and Manonnmani (2011), Ghavidel and Mehdi (2011), Deshmukh (2013), Chandrika *et al*., (2013), Savitha and Chandra (2013), Digumarthy Niharika *et al*., (2020), Wei Yu *et al*., (2020) and Matheus and Padilha *et al*., (2021).

Phenotypic Correlation

The seed yield character of the study recorded significant positive correlation with primary branches per plant (0.590), days to maturity (0.5956), days required for shattering (0.3937), number of pods per cluster (0.493), number of pods per plant (0.6727), 100 seed weight (0.533), root and shoot length (0.4605) while it was non-significantly positive correlated to the number of seeds per pod (0.0719). It also reported significant negative correlation with length of pod (-0.4751), Seed hardness (-0.3584). However, it also reported non-significant negative correlation with days to 50% flowering (-0.2037) andplant height (-0.062).

The number of primary branches might be developed into more number of pod clusters which resulted in high seed yield per plant. Such results were also revealed by Singh *et al.,* (1977), Kumar *et al.,* (2004), Khajudparn and Tantasawat (2011), Nana and Anuradha (2013), Ahmed *et al*., (2015), Ghimir e*et al*., (2017), Kritika and Yadav (2017).

Table 4.7: Correlation studies of genotypes on seed yield with different yield contributing characters in Mung beanalong with quality and biochemicaltraits in mung bean

	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Days req. For shattering	Prim. Branchesper plant	No. of podsper cluster	pods per plant	length of pod (cm)	No. of seedsper pod	100 seed weight (g)
Days to 50% Flowering	**1.000**									
Days to Maturity	-0.1329	**1.000**								
Plant Height (cm)	0.0599	-0.227	**1.000**							
Days req. For shattering	-0.2306	0.2394	-0.4433 **	**1.000**						
Prim. Branches per plant	-0.4672 **	0.0705	-0.4858 **	0.2602	**1.000**					
No. of pods per cluster	-0.4666 **	0.0824	-0.2798	0.2661	0.5303 **	**1.000**				
pods per plant	-0.506 **	0.2876	-0.305	0.3282	0.5417 **	0.837 **	**1.000**			
length of pod (cm)	0.3601 *	-0.4807 **	0.0257	-0.1421	-0.228	-0.4021 *	-0.5709 **	**1.000**		
No. of seeds per pod	0.2573	-0.3147	-0.3526 *	0.391 *	0.2011	0.0622	-0.0517	0.3963 *	**1.000**	
100 seed weight (g)	0.2394	-0.5374 **	0.3785 *	-0.1919	-0.2372	-0.4229 *	-0.5452 **	0.805 **	0.1962	**1.000**
harvest index (%)	0.265	-0.2298	0.1898	-0.2624	-0.1701	0.1129	-0.2643	0.3454 *	0	0.1023

Table 4.8 Correlation on seed quality with different quality parameters along with biochemical enzyme alpha amylase

	Harvest Index (%)	Germination (%)	Root and Shoot Length (cm)	Vigor Index I	Alpha amylase (mg/g)	Seed Hardness (Kg/cm^2)	Seedling dry wt (g)	Vigor Index II	Pod Opening time (hrs)	Seed yield per plant(g)
harvest index (%)	**1.000**									
Germination (%)	0.178	**1.000**								
Root and Shoot Length (cm)	0.1339	0.0246	**1.000**							
Vigor Index I	0.0979	0.0035	0.9765 **	**1.000**						
Alpha amylase (mg/g)	-0.2031	0.734**	0.1012	0.736**	**1.000**					
Seed Hardness (Kg/cm^2)	0.0082	0.6794 **	-0.5598 **	-0.6007 **	-0.3568 *	**1.000**				
Seedling dry wt (g)	-0.1361	0.3098	-0.5074 **	-0.4375 **	-0.5671 **	0.6165 **	**1.000**			
Vigor Index II	-0.2068	0.0022	0.8642 **	0.8866 **	0.605**	-0.5041 **	-0.4031 *	**1.000**		
Pod Opening time (hrs)	0.1475	8e-04	0.8707 **	0.9018 **	-0.636**	-0.6524 **	-0.5491 **	0.8013 **	**1.000**	
Seed yield per plant (g)	-0.1597	-0.0899	0.4605 **	0.5434 **	0.2377	-0.3584 *	0.0075	0.5695 **	0.4025 *	**1.000**

The trait pods/plant showed similar results by Malhotra *et al*., (1974), Rathnaswamy *et al*., (1978), Upadhyaya *et al*., (1980), Khanpara *et al*., (2012), Das and Barua (2015) and Parihar *et al.,* (2018).

The similar results were also found by Deore, (1983), Dixit *et al*., (2002), Haritha and Reddy Sekhar, (2002), Kumar *et al*., (2004), Gupta *et al*., (2005), Gul *et al*., (2008), Vinay *et al*., (2010), Gadakh *et al*., (2013) and Dhoot*et al*., (2017). They suggested, while selecting for improvement of lines in seed yield, these characters can be keep in mind for selection.

The enzyme α-amylase showed significant positive correlation with germination percentage, vigour index I and vigour index II. Enzyme α-amylase estimated high range of positive correlation with germination percentage, vigour index I & II and negatively correlated with pod opening time. (Table 4.4).

This indicates the strong association of enzyme α-amylase with germination percentage, vigour index I & II.

It mean increase in enzyme activity of α-amylase with increased germination percentage, vigour index I, vigour index II and *vice-versa*.

Similar results were found by Bain and Mercer (1966), Abdul-Baki and Anderson (1972) reported amylase is responsible for embryo growth which resulted into seedling growth in germinating seeds. Dyer and Movellie (1976) also reported that increase in alfa-amylase activity in cereal seed results in higher germination percent. Such results were also reported by Wadhwa *et al.* (1988), Shigeshi *et al.* (1991), Mohammed Yaseen (1994), Desai (2004), Rahman et al., (2009), Mohankumar and Manonnmani (2011), Ghavidel and Mehdi (2011), Deshmukh (2013), Chandrika *et al*., (2013), Savitha and Chandra (2013), Digumarthy Niharika *et al*., (2020), Wei Yu *et al*., (2020) and Matheus and Padilha *et al*., (2021).

CHAPTER -V

SUMMARY AND CONCLUSION

CHAPTER - VI

SUMMARY AND CONCLUSION

The present investigation entitled "**Effect of alpha amylase on seed germination in mungbean**" has been undertaken at Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani with the following objectives:

1. Effect of alpha amylase on seed germination in mungbean *Vigna radiata* (L.)
2. To study the enzyme responsible for germination of seed.
3. To study Correlation studies of enzyme on seed quality.

The experimental material included in the present study comprised of 12 genotypes including 5 checks *viz;* BM-4, BPMR-145, BM-2003-2, Vaibhav & Utkarsh was evaluated during *kharif* 2021 at VNMKV, Parbhani. Observations were recorded on the characters *viz;* days to 50% flowering, days to maturity, plant height, days required for shattering, number of primary branches per plant, number of pods per cluster, number of pods per plant, length of pod, number of seeds per pod, 100 seed weight, seed yield / plant (g), harvest index, germination percentage, root and shoot length, vigor index I, seed hardness (kg/cm^2), alpha amylase (mg/g), seedling dry wt (g), vigor index II and pod opening time.

The most of the cases, the genotypic correlation coefficients were found to be higher magnitude than the corresponding phenotypic one.

Alpha amylase is positively correlated with germination, vigour index I and vigour index II but it is negatively corelated with pod opening time, due to alpha amylase responsible for germination.

The variation due to genotypes were significant for all the characters under study both at 5% and 1% probability levels in both season. The significant differences in characters indicate the presence of variability in experimental material.

In genotypic correlation, the seed yield character of the study recorded significant positive correlation with primary branches per plant, days to maturity, days required for shattering, number of pods per cluster, number of pods per plant, 100 seed weight while, it was non-significantly positive correlated to the number of seeds per pod, root and shoot length. It also reported non-significant negative correlation with days to 50% flowering, plant height, length of pod and harvest index. The number of primary branches might be developed into more number of pod clusters which resulted in high seed yield per plant.

The enzyme α-amylase showed significant positive correlation with germination percentage in all the genotypes and in case of **Vishal** α-amylase was minimum and also germination percentage was lowest which shows that less amount of α-amylase enzyme content in pod results in reduced viviparous germination percentage and also requires more days for pod opening.

vigour index I and vigour index II. Enzyme α-amylase estimated high range of positive correlation with germination percentage, vigour index I & II and negatively correlated with pod opening time. This indicates that strong association of enzyme α-amylase with germination percentage.

It means increase in enzyme activity of α-amylase increases germination percentage of seed in mungbean.

In correlation study of seed quality parameters with alpha amylase, it shows significant and positive correlation with germination percentage, root and shoot length, vigor index I & II, seed hardness, seedling dry weight. and, shows non-significant negative correlation with pod opening time

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APPENDIX

APPENDIX- I

WEEKLY WEATHER DATA 2021-22

Week	RF	Temperature ^{0}C		Humidity (%)		EVP (mm)	BSS (Hrs.)	WS (Kmph)
		Max	Min	RH1	RH2			
20-26 Nov 20	0.0	32.2	17.2	83	43	4.2	8.2	2.5
27-3 Dec20	0.0	29.7	15.2	80	41	4.7	6.6	4.8
04-10 Dec 20	0.0	31.0	9.2	86.6	27.0	4.8	9.3	2.9
11-17 Dec 20	0.0	30.3	14.8	83.1	34.9	4.1	7.2	2.8
18-24 Dec 20	0.0	28.8	10.2	89.0	36.0	4.0	7.9	2.9
25-31 Dec 20	0.0	32.7	10.8	97.9	37.9	4.4	3.3	2.8
01-07 Jan 21	0.0	28.8	15.4	88.0	51.0	3.7	4.3	3.8
08-14 Jan 21	0.0	31.0	15.3	90.0	40.0	4.4	6.3	3.1
15-21 Jan 21	0.0	31.2	15.1	82.0	35.0	4.4	7.6	3.1
22-28 Jan 21	0.0	31.7	13.6	83.0	34.0	4.3	8.2	2.5
29-05 Feb 21	0.0	30.3	12.9	78.0	29.0	5.2	7.4	3.4
06-12 Feb 21	0.0	30.2	11.3	66.0	20.0	5.9	9.4	3.0
13-19 Feb 21	1.8	32.4	14.3	76.0	34.0	5.6	8.7	2.8
20-26 Feb 21	14.5	30.3	13.0	93.0	40.0	4.5	7.7	3.4
27-05 Mar 21	0.0	31.8	13.6	59.0	12.0	6.3	7.9	2.6
06-12 Mar 21	0.0	36.6	16.6	61.0	14.0	7.1	9.3	2.6
13-19 Mar 21	0.0	36.8	16.8	60.0	21.0	7.5	9.0	3.0
20-26 Mar 21	14.3	34.9	20.1	74.0	28.0	6.9	7.0	5.0
27-01 Apr 21	0.0	39.3	16.0	57.0	12.0	9.1	9.2	3.3
02-08 Apr 21	0.0	39.4	19.2	48.0	11.0	10.1	9.2	3.8

CURRICULUM VITAE

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Academic qualification:

Course/ Degree	**Name of the college/institute**	**University /Board**	**Year of Passing**	**Percentage (%) / CGPA**	**Class/ Grade**
SSC	English Schhol Narkhed ,Mohol.	Pune	March 2014	88	First class
HSC	S.M.V. Akluj.	Pune	March 2016	72	First class
B. Sc. (Agri)	L.M.K.Collage of Agriculture, Kadegaon.	M.P.K.V. Rahuri	June 2020	81	First class

Place: Parbhani

Date: 30 / 11 /2022

Shete

(Shete Pruthviraj Sanjay)