



Phenotypic Identification and Diversity of Mung Bean Germplasm in Liaoning, China

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ABSTRACT

Background: Mung bean (*Vigna radiata* L.) has a short growth period, long suitable sowing period, drought and barren tolerance, wide adaptability, nitrogen fixation and other characteristics. China is one of the original centers of mung bean, with a cultivation history of more than 2000 years. The current study aimed to assess the present mung bean germplasm in Liaoning Province scientifically, to provide a theoretical basis for collection, preservation, innovative and usage of mung bean germplasm resources.

Methods: This study was conducted during 2011-2015 and 170 mung bean germplasm collections were selected from the germplasm resource bank of Liaoning Academy of Agricultural Sciences. Fourty six agronomic traits, including 34 quality traits and 12 quantitative traits, were observed and recorded. Data were comprehensively evaluated by multivariate analysis, *i.e.*, diversity analysis, principal component analysis, correlation analysis, grey relational analysis and cluster analysis.

Result: It was observed that mung bean resources have abundant diversity for exploitation in breeding programs. The traits pod-bearing capacity and vegetative growth capacity of plants were found closely related to yield. Germplasm lines with superior performance for yield characteristics, growth period, plant height and grain size were selected which included one high-yield and one early-matured and high-yield resource.

Key words: Agricultural trait, Diversity analysis, Germplasm resources, Mung bean, Phenotypic identification.

INTRODUCTION

Mung bean (*Vigna radiata* L.) is an important cultivated species in the *Phaseoleae* family of Leguminosae (*Papilionaceae*) (Long *et al.*, 1989). It has been developed and domesticated as an important food crop for a long time. China is one of the original centers of mung bean, with a cultivation history of more than 2000 years (Zheng, 1997; Cai and Wang, 2007). Mung bean is mainly distributed in Northeast China, North China Plain and the Huang and Huai River Basin. Mung bean has a short growth period, long suitable sowing period, drought resistance, barren tolerance, wide adaptability, nitrogen fixation and other characteristics. Alternatively, mung bean can be used as a grain and vegetable, food and medicine, with high economic value.

Germplasm resources research is the basis in any crop research. In recent years, especially after establishing the National Edible Bean Industry and Technology System, China had intensified research on edible bean germplasm resources. In terms of mung bean research, Chen *et al.* (2020) and Qiao *et al.* (2015) collected hundreds of mung bean resources from home and abroad, analyzed and evaluated their agronomic traits and genetic diversity and it is believed that mung bean has high variability for most of the phenotypic traits and selected germplasm selections possess excellent characteristics and superior for most of the traits. A total of 7067 mung bean germplasm resources were collected, preserved and catalogued in the National Germplasm Bank of China and most of them were identified for main agronomic traits, which were included in the Catalog of Edible Bean Germplasm resources of China and the core germplasm of mung bean was constructed (Liu *et al.*,

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2008). Based on this, Wang *et al.* (2014) evaluated the phenotypic variation and ecological adaptability of mung bean core germplasm resources and believed that the growth habit and pod-setting habit of mung bean were significantly affected by the ecological environment. Simultaneously, Bisht *et al.* (1998) also made a comprehensive evaluation of mung bean resources in India and constructed the core germplasm population. With the progress of technology, molecular biology technology has been applied to genetic diversity analysis of mung bean resources, Chen *et al.* (2015) compared 157 cultivated and wild germplasms from East Asian regions by SSR markers and found that the polymorphism was low and hence there was a need to collect resources widely. Singh *et al.* (2009) compared 12 traits in mung bean resources in three ecological areas and clustered 80 resources into 11 groups, indicating that mung bean resource panel has a rich diversity. Kumar *et al.* (2012) analyzed the diversity of 48 mung bean resources with different origins using ISSR, URP and SSR

distance-deviation square sum method and further K-mean cluster analysis was conducted on the basis of quantitative traits.

RESULTS AND DISCUSSION

Diversity analysis of mung bean germplasm resources

Among the 34 tested qualitative traits, nine exhibited the same characteristics, *i.e.*, 70-90 d growth period, green unearthed cotyledon, single green leaf, whole margin three-compound leaves, infinite podding, mature pod brown with cylindrical shape and brown pod fuzz. Twenty five qualitative traits exhibited different characteristics, of which 12 traits exhibited all the characteristics listed in criteria (Cheng *et al.*, 2006) and 13 traits exhibited partial characteristics. Among the traits, grain color was the most complex, showing 4 of the 5 characteristics. Leaf shape, leaf color, plant fuzz growth conditions and color showed an obvious tendency, whereas growth habit, pod splitting and grain size were scattered.

For the 12 quantitative traits, the coefficient of variation (CV) of all resources in this experiment ranged from 2.44% to 60.10%. CV of plant yield (PY), pod number per plant (PNP) and main stem branch number (BRN) were over 30%, showing that the variation range of these three traits was large and the potential of genetic improvement was large, the same result was found by Kumar *et al.* (2020) in faba bean and Saidaiah *et al.* (2021) in cow bean. CV of growth period (GP) was the lowest, indicating that the natural climate conditions in this region limited the growing period of mung bean resources. Shannon diversity index (DI) ranged from 0.979 to 2.054. Plant height (PH), leaf size (LS), growth period (GP) and 100-grain weight (HSW) recorded the higher Shannon DI, showing that these four traits had the most abundant phenotypes and the largest range of parents to choose from. The DI of seed length (SL) was the smallest at only 0.979, while the CV was also small (15.19%); as mung bean grains were smaller, so the amplitude of variation was small and the selection range was limited.

Comparison of CV and Shannon DI of mung bean resources, for 46 tested traits showed rich diversity, Win *et al.* (2020) got the same result while Saidaiah *et al.* (2021) got similar result on cowpea. GP (the number of growing days) and some traits showed strong adaptability through natural and artificial selection in the long-term evolution process and their potential for genetic improvement was negligible, which was in agreement with the earlier results of Gao *et al.* (2020). However, the traits showing remarkable differences and rich diversity are either directly related to yield or indirectly affecting yield on behalf of plant growth and development, which indicates that mung bean resources still have great potential for yield improvement.

Correlation analysis of quantitative traits

Except for GP and HSW, all other traits were positively

correlated with plant yield (PY), of which the most significant correlated traits were PNP, followed by PH, BRN and main stem diameter (MSD). It can be seen that pod-bearing capacity and plant development state had great impact on yield. Comparing the correlation coefficients of other essential traits, with an increase in GP, stem node number (SNN) increases, but the pod bearing capacity decreased, which notably led to a decrease in yield. The resources with vigorous growth and bigger pods and seeds have bigger HSW, while the increase of pods number per plant (PNP) inevitably led to smaller pods and seeds, but seeds number per pod (NSP) increased accordingly. There was a significant positive correlation between seed length (SL) and NSP, while a significant positive correlation between each index of vegetative growth of the plant, these results were in line with expectations.

Grey relational analysis of quantitative traits

After standardized processing, grey relational analysis was conducted in the measured values of 12 quantitative traits of mung bean resources. The results indicate that pod-bearing capacity and plant development ability were closely correlated with yield. Generally, the results of grey relational analysis and correlation analysis were consistent, *i.e.*, the yield was mainly limited by the pod-bearing capacity of the plant and was directly related to the vegetative growth of the plant, whereas the impact of GP and seed size (SS) on the yield was limited.

Principal component analysis of quantitative traits

Five principal components with eigen values bigger than or close to 1 were selected. By comparing the eigen vectors of each principal component, it could be named as the HSW factor, GP factor, PL factor, PH factor and NSP factor. The first, third and fifth components were directly related to yield and more emphasis should be done in these traits while selecting high-yielding varieties. The fourth component represents plant development, which is indirectly related to yield should also be considered during selection. The second component represents the period of growth and can be utilized according to the specific situation.

Combining the results of the correlation studies and grey relational analysis, it can be concluded that the yield of mung beans is mainly determined by the pod-bearing capacity and growth status of the plant. The results of the principal component analysis also support this conclusion. This conclusion is consistent with the research findings of Hou *et al.* (2015) and Yang *et al.* (2015).

Cluster analysis and evaluation

Based on all the 46 traits with different performance (12 quantitative traits + 34 quality traits) of mung bean resources, this study adopted a standardized data transformation-Euclidean distance-deviation square sum method to conduct cluster analysis and all the accessions were divided into seven groups at Euclidean distance = 27.59 (Fig 2).

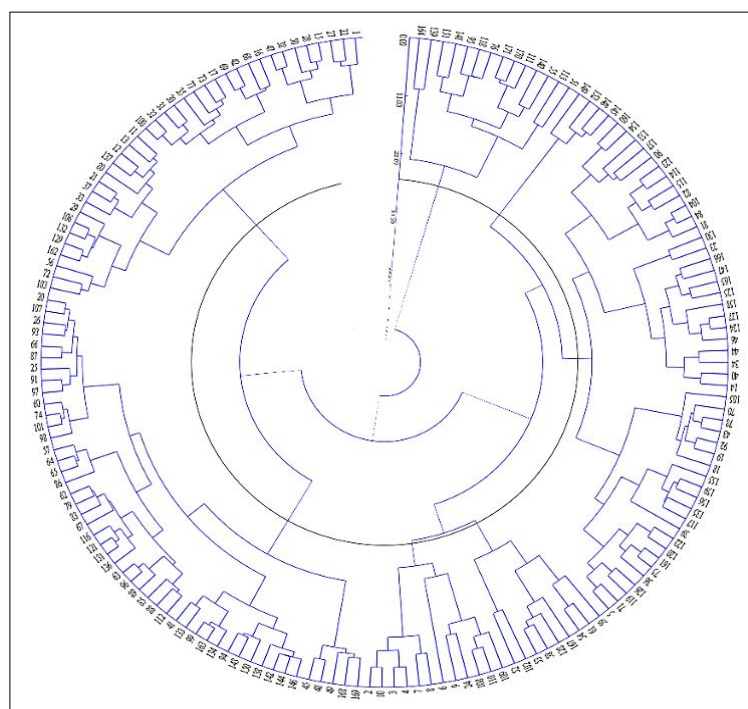


Fig 2: Cluster analysis of 170 *Vigna radiata* L. germplasm.

The first group consists of 36 samples, which were later-maturing, dwarf and low-yield. The second group consists of 49 samples, which recorded big-pod and big-seed size and strong-stem. The third group represented 11 accessions which were late-maturing, multi-nodule and small-seeded. The fourth group contained nine samples, which were dwarf, big-podded and low-yielding types. The fifth group contains 47 samples, which were late-maturing and with small-pods, small-seeds. The sixth group contains four samples, which were early-maturing accessions with big-grain and high-yield. Finally, the seventh group comprised 14 samples, with big-leaf, big-grain and high-yield.

All groups showed two kinds of compound leaves, *i.e.* triangular and oval shapes with relatively uniform distribution and two kinds of seed skin characteristics namely bright and grey and mainly bright. The other traits exhibited differences among different groups. Group II showed the main characteristics of resources in this region. Groups III and VI exhibited more uncommon characteristics. The traits of group V showed abundant characteristics. Group VII is a special group, with certain traits performance in contrary to other groups.

K-mean clustering analysis

The theoretical distribution intervals and central values of the 12 quantitative traits were set for the experimental material. The traits of germplasm studied in this experiment were mainly concentrated near the central value, which was also the main characteristic of mung bean germplasm resources in Liaoning Province. Based on the results, No. 130 resource was outstanding for yield and its yield

Table 1: K-mean cluster analysis of *Vigna radiata* L.

	Character	Min	Mean	Max
Stem	GP (d)	79.21	82.79	85.52
	PH (cm)	47.97	66.79	85.67
	LS (cm ²)	56.37	84.87	117.32
	MSD (cm)	0.55	0.79	1.02
	SNN	6.65	9.03	11.23
Pod	BRN	2.29	4.65	7.60
	PNP	20.86	43.84	92.20
	PL (cm)	7.71	10.01	12.17
Seed	NSP	8.17	11.28	13.62
	SL (cm)	0.30	0.40	0.51
	HSW (g)	5.07	6.29	7.87
	PY (g)	20.40	50.62	96.50

potential is good. No. 149 resources combined high yield and earliness in maturity. Simultaneously, four large-grain resources, 15 early-maturing resources and multi-pods resources, high-stems resources, lobules resources, as well as other resources with outstanding usable characteristics were screened out, which could be referenced in breeding (Table 1).

CONCLUSION

In summary, mung bean resources in Liaoning have rich diversity in phenotype and there are close correlations between different traits. Based on the results of multivariate analyses, it was concluded that pod-bearing capacity and vegetative growth ability were closely related to yield.

Therefore, with respect to high yield breeding, germplasm resources with more pods per plant, bigger pod size, bigger seeds and vigorous growth should be selected for further utilization. Furthermore, resources with outstanding usable characteristics were screened out, include one high-yield resource from Beipiao and one early-maturing high-yield resource from Tieling of Liaoning Province, provides a good chance for the selection of parents for the improvement program.

Conflict of interest: None.

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