Evaluation of Germplasm Accessions for Drought Tolerance in Green gram [Vigna radiata (L.)]

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ABSTRACT

An experiment was conducted to screen 200 germplasm accessions of green gram for drought tolerance using augmented design during summer 2015 under drought stress condition. ANOVA revealed high significant differences among germplasm accessions for yield, yield component traits and also for drought tolerance traits. Mean squares attributable to ‘Genotypes vs check entries’ were significant for all the traits except seeds per podand relative water content. Genotypic coefficient of variation and phenotypic coefficient of variation were found to be on higher side for grain yield, yield components such as clusters per plant, pods per cluster and pods per plant. Higher values of GCV and PCV were also observed for drought tolerance traits such as chlorophyll content (spad chlorophyll meter reading), leaf water potential, proline content, relative water content and specific leaf area. The grain yield, yield component traits and drought tolerance traits exhibited high heritability (broad sense) coupled with high to moderate expected GAM.

Keywords
Green gram germplasm, GCV, PCV and Heritability

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Introduction

Among pulse crops, green gram is an important annual legume grown principally for its high protein seeds that are used as human food (Singh et al., 1988). The wild mung bean progenitor of present day cultivated species is widely distributed in the
Godavari and Krishna river belts of south India and in the foothills of western Himalaya of Eastern India (Fuller, 2007; Smartt, 1990). Important beneficial factors making the green gram crop popular are; short duration (90-120 days), nitrogen fixing ability, inhibition of soil erosion, soil enrichment, low input requirements and wide adaptability.

Despite holding such a great promise, mung bean is often grown in mostly rain-fed marginal lands with limited inputs making it prone to a number of abiotic stresses. Among these stresses, drought is the major stress leading to heavy crop loss. Water is required for almost every aspect of plant growth and metabolism and its shortage affects various physiological and biochemical processes (Ahmad et al., 2014).

Soil moisture deficit is a multidimensional stress affecting plants at various levels of their organization (Yordanov, 2000). Beebe et al., (2013) reported that adaptation to drought, encompasses diverse mechanisms that enable plants to survive and produce in periods of drought stress. Single trait taken alone cannot be a good indicator of drought, since a number of traits jointly influence yield under drought stress (Kao et al., 1994).

Green gram is reported to be more susceptible to water deficits than any other grain legumes. Reduction in crop photosynthesis is caused by reduction in plants leaf leading to dry matter accumulation (Pandey et al., 1984). Siddiqui et al., (2007) reported that pod setting stage and late flowering traits appear to be the most sensitive stages to soil moisture stress and yield.

Various physiological processes associated with growth, development, and economic yield of a crop are affected due to water stress (Allahmoradi et al., 2011). Breeding efficiency for drought tolerance heavily relies on need to identify the specific physiological, biochemical and genetically controlled traits that may improve yields under drought stress condition.

So far, the drought stress has not been properly dissected into its different components at physiological, bio-chemical, genetic and molecular genetics levels. Only limited information is available in pulse crops, placing constraints in designing an appropriate breeding methodology to facilitate genetic improvement.

Materials and Methods

The experiment was conducted at experimental plot of College of Agriculture, Hassan, University of Agricultural Sciences, Bangalore. The experimental site is geographically located at Southern Transitional Zone (Zone-7) of Karnataka with an altitude of 827 m above Mean Sea Level (MSL) and at 33′ N latitude and 75° 33′ to 76° E38′ longitude. The study material consisted of 200 germplasm accessions collected from different research institutions / organizations representing different agro-climatic zones. List of germplasm accessions used in the study with their source is given in table No1.

Layout of the experiment

The experiment was conducted in an Augmented Randomized Complete Block Design with 200 germplasm accessions and 5 check varieties. As per the augmented RCBDS, the check entries were replicated twice randomly in each block. There were 5 blocks, each block had 5 plots of size 3x3 m² thus each block size was 15 m². The gross area of experimental plot was 75 m². The row spacing was 30 cm and inter plant distance was 10 cm. The experiment was conducted during summer 2015. Recommended crop production practices were followed during the crop growth period to raise healthy crop.
Imposing drought condition

Drought condition was imposed by withholding irrigation 25 days after sowing (Baroowa and Gogoi, 2015; Pooja et al., 2019). Since the experiment was conducted during summer season, there were no unpredicted rains during the entire cropping period hence the drought condition was effectively imposed. The rainfall data of experimental site during the cropping period is given in table No.2.

Plant sampling and data collection

Observations were recorded on five randomly chosen competitive plants from each germplasm accession for all the characters except days to 50 per cent flowering and days to maturity, which were recorded on plot basis. The values of five competitive plants were averaged and expressed as mean of the respective characters. The observations were taken on the traits like; Days to 50% flowering, Days to maturity, Plant height (cm), Clusters per plant, Pods per cluster, Pods per plant, Pod length (cm), Seeds per pod, test weight, Threshing %, Harvest index (%),SCMR (SPAD Chlorophyll meter reading), Leaf water potential(Mpa), Proline content (μg g⁻¹), Relative water content, Specific leaf area and Seed yield per plant

Results and Discussion

Assessment of genetic variability for grain yield and its component traits

For successful crop improvement programmes, breeders need to define and assemble the required genetic variability and select for yield indirectly through yield associated and highly heritable characters (Mather, 1949). Selection is only effective if the trait has high heritability otherwise attempts to improve character through selection will be futile.

Analysis of variance

Analysis of variance revealed highly significant mean squares attributable to germplasm accessions for all the traits. Significant mean squares were recorded for all the traits. (Table 3). Mean squares attributable to ‘Genotypes vs check entries’ were significant for all the traits except seeds per pod and relative water content. These results suggest significant differences among the germplasm accessions. The germplasm accessions as group differed significantly for all of the traits under investigation, similarly, check entries as group differed significantly for most the traits under study.

Descriptive statistics for yield parameters

Genetic variability is a pre-requisite for quantifying variability and assessing relative contribution of genetic and non-genetic sources on the quantitative traits which is useful in formulating appropriate selection strategies. The mean and range values do not reflect the total variability present in the material.

Hence, actual variance has to be estimated for the traits to know the extent of variability existed in them. The absolute values of phenotypic and genotypic variance can’t be used for making comparison of degree of variability across characters as they the traits differ in their units of measurement. Hence, co-efficient of variation (PCV and GCV) which are free from measurement units are used for making comparison. Higher values for these parameters indicate large variability and vice versa.

The values of different descriptive statistics in given in table 4. Days to 50 per cent flowering varied from 33.00 days to 60.00 days with a
mean of 41.61 days. Days to maturity varied from 60.00 days to 81.00 days with a mean of 69.14 days. Plant height ranged from 19.18 cm to 58.57 cm with mean value of 37.74 cm. Values of cluster per plant varied from 1.53 to 8.25 with mean value of 5.00. Minimum value of 1.75 and maximum value of 4.50 with mean value of 3.23 was observed for the trait pods per cluster. Pods per plant had range of values from 4.38 to 35.72 with mean value of 16.81. Pod length varied from 4.05 to 7.67 with mean value of 5.83. Seeds per pod ranged from 3.07 to 9.70 with a mean of 6.63.

Minimum and maximum values for the trait test weight were 1.71 gms and 5.49 gms respectively with mean value of 3.45 gms. Threshing percentage varied from 42.89 per cent to 76.93 per cent with mean value of 62.03 per cent. Minimum value of 20.52 and maximum value of 55.95 with mean value of 35.11 was observed for the trait harvest index. Spad chlorophyll meter reading had range of values from 36.59 to 87.41 with mean value of 55.55. Leaf water potential varied from -8.14 Mpa to -2.16 Mpa with mean value of -5.74. Proline content values ranged from 62.70 (μg g⁻¹) to 201.33 (μg g⁻¹) with mean value of 120.98 (μg g⁻¹). Relative water content recorded lowest value of 33.63 and highest value of 97.18 with a mean of 68.59. Specific leaf area had a minimum value of 31.96 and maximum of 298.29 with mean value of 156.52. Seed yield per plant ranged from 0.74 gms to 11.05 gms with a mean value of 4.02 gms. The estimates of standardized range across traits provide clues about the occurrence of genotypes with extreme expression.

The standardized range were relatively higher for all the quantitative traits such as; plant height (1.04), cluster per plant (1.34), pods per cluster (0.85), pods per plant (1.87), pod length (0.62), seeds per pod (1.00) test weight (1.10), threshing percentage (0.55), harvest index (1.01), spad chlorophyll meter reading (0.91), leaf water potential (-1.04), proline content (1.15), relative water content (0.93), specific leaf area (1.70) and seed yield per plant (2.56) except for days to 50% flowering (0.48) and days to maturity (0.30). Higher ranges for plant height and other traits in green gram are reported by Muthuswamy et al., (2019).

Table 1 List of germplasm accessions used in the study and their source

| Sl. No. | Germplasm | Location |
|---------|-----------|----------|
| 1       | KM13-16   | ARS, Bidar |
| 2       | KM13-19   | ARS, Bidar |
| 3       | KM13-39   | ARS, Bidar |
| 4       | GG13-7    | ARS, Bidar |
| 5       | GG13-6    | ARS, Bidar |
| 6       | KM13-44   | ARS, Bidar |
| 7       | GG13-10   | ARS, Bidar |
| 8       | SML-668   | ARS, Bidar |
| 9       | KM13-9    | ARS, Bidar |
| 10      | IPM99-125 | ARS, Bidar |
| 11      | LGG-596   | RARS, Guntur |
| 12      | LGG-572   | RARS, Guntur |
| 13      | LGG-450   | RARS, Guntur |
|   |   |   |
|---|---|---|
| 14 | LGG-583 | RARS, Guntur |
| 15 | LGG-590 | RARS, Guntur |
| 16 | LGG-588 | RARS, Guntur |
| 17 | LGG-589 | RARS, Guntur |
| 18 | LGG-579 | RARS, Guntur |
| 19 | LGG-562 | RARS, Guntur |
| 20 | LGG-582 | RARS, Guntur |
| 21 | LGG-585 | RARS, Guntur |
| 22 | AKL-170 | NBPG, Akola |
| 23 | PLM-110 | UAS, Bangalore |
| 24 | LGG-577 | RARS, Guntur |
| 25 | IC-436624 | IIPR, Kanpur |
| 26 | IC-436723 | IIPR, Kanpur |
| 27 | IC-433116 | IIPR, Kanpur |
| 28 | IC-436746 | IIPR, Kanpur |
| 29 | VGG10-010 | TNAU, Coimbatore |
| 30 | VGG04-011 | TNAU, Coimbatore |
| 31 | VGG04-007 | TNAU, Coimbatore |
| 32 | COGG-93 | TNAU, Coimbatore |
| 33 | VBNNG-2 | TNAU, Coimbatore |
| 34 | TARM-2013 | TNAU, Coimbatore |
| 35 | VGG04-005 | TNAU, Coimbatore |
| 36 | COGG-920 | TNAU, Coimbatore |
| 37 | VGG07-003 | TNAU, Coimbatore |
| 38 | VGG10-002 | TNAU, Coimbatore |
| 39 | VGG-112 | TNAU, Coimbatore |
| 40 | IC-92048 | NBPG, Akola |
| 41 | AKL-103 | NBPG, Akola |
| 42 | AKL-39 | NBPG, Akola |
| 43 | AKL-106 | NBPG, Akola |
| 44 | AKL-225 | NBPG, Akola |
| 45 | AKL-95 | NBPG, Akola |
| 46 | AKL-194 | NBPG, Akola |
| 47 | AKL-212 | NBPG, Akola |
| 48 | AKL-195 | NBPG, Akola |
| 49 | AKL-211 | NBPG, Akola |
| 50 | KM13-11 | ARS, Bidar |
| 51 | KM13-30 | ARS, Bidar |
| 52 | KM13-45 | ARS, Bidar |
| 53 | KM13-18 | ARS, Bidar |
| 54 | KM13-5 | ARS, Bidar |
| 55 | KM13-02 | ARS, Bidar |
| 56 | KM13-37 | ARS, Bidar |
| No. | Code      | Location             |
|-----|-----------|----------------------|
| 57  | KM13-23   | ARS, Bidar           |
| 58  | KM13-55   | ARS, Bidar           |
| 59  | KM13-12   | ARS, Bidar           |
| 60  | GG13-9    | ARS, Bidar           |
| 61  | KM13-49   | ARS, Bidar           |
| 62  | GG13-4    | ARS, Bidar           |
| 63  | GG13-54   | ARS, Bidar           |
| 64  | KM13-20   | ARS, Bidar           |
| 65  | GG13-5    | ARS, Bidar           |
| 66  | Chinamung  | ARS, Bidar           |
| 67  | GG13-2    | ARS, Bidar           |
| 68  | KM13-26   | ARS, Bidar           |
| 69  | KM13-47   | ARS, Bidar           |
| 70  | KM13-41   | ARS, Bidar           |
| 71  | KM13-11   | ARS, Bidar           |
| 72  | KM13-42   | ARS, Bidar           |
| 73  | GG13-11   | ARS, Bidar           |
| 74  | GG13-8    | ARS, Bidar           |
| 75  | GG13-12   | ARS, Bidar           |
| 76  | KM13-48   | ARS, Bidar           |
| 77  | IPM2-3    | ARS, Bidar           |
| 78  | IPM2-14   | ARS, Bidar           |
| 79  | PDM-139   | ARS, Bidar           |
| 80  | LGG-580   | RARS, Guntur         |
| 81  | PM-112    | TNAU, Coimbatore     |
| 82  | LGG-578   | NBPG, Akola          |
| 83  | LGG-563   | NBPG, Akola          |
| 84  | LGG-594   | NBPG, Akola          |
| 85  | TM-96-2   | NBPG, Akola          |
| 86  | LGG-593   | NBPG, Akola          |
| 87  | LGG-591   | NBPG, Akola          |
| 88  | PM-115    | NBPG, Akola          |
| 89  | LGG-587   | NBPG, Akola          |
| 90  | PM-113    | NBPG, Akola          |
| 91  | LGG-586   | NBPG, Akola          |
| 92  | IC-436775 | NBPG, Akola          |
| 93  | IC-413311 | NBPG, Akola          |
| 94  | IC-398984 | NBPG, Akola          |
| 95  | IC-436767 | NBPG, Akola          |
| 96  | IC-436573 | NBPG, Akola          |
| 97  | LGG-584   | NBPG, Akola          |
| 98  | LGG-592   | NBPG, Akola          |
| 99  | LGG-555   | NBPG, Akola          |
|   | Code  | Institution          |
|---|-------|---------------------|
|100| LGG-564 | NBPG, Akola        |
|101| LGG-460 | RARS, Guntur          |
|102| LGG-595 | RARS, Guntur          |
|103| LGG-566 | RARS, Guntur          |
|104| IC-553514 | IIPR, Kanpur    |
|105| IC-413319 | IIPR, Kanpur    |
|106| IC-436542 | IIPR, Kanpur    |
|107| IC-546493 | IIPR, Kanpur    |
|108| IC-436594 | IIPR, Kanpur    |
|109| IC-436630 | IIPR, Kanpur    |
|110| IC-436668 | IIPR, Kanpur    |
|111| IC-436555 | IIPR, Kanpur    |
|112| IC-413314 | IIPR, Kanpur    |
|113| AKL-20 | NBPG, Akola           |
|114| AKL-89 | NBPG, Akola           |
|115| AKL-228 | NBPG, Akola           |
|116| AKL-184 | NBPG, Akola           |
|117| AKL-182 | NBPG, Akola           |
|118| AKL-230 | NBPG, Akola           |
|119| AKL-229 | NBPG, Akola           |
|120| AKL-86 | NBPG, Akola           |
|121| IC-436646 | IIPR, Kanpur    |
|122| IC-343964 | IIPR, Kanpur    |
|123| IC-436528 | IIPR, Kanpur    |
|124| IC-436723 | IIPR, Kanpur    |
|125| IC-546491 | IIPR, Kanpur    |
|126| IC-546481 | IIPR, Kanpur    |
|127| IC-398988 | IIPR, Kanpur    |
|128| VGG10-005 | TNAU, Coimbatore |
|129| VBN-223 | TNAU, Coimbatore |
|130| COGG-912 | TNAU, Coimbatore |
|131| VBN(G9)-3 | TNAU, Coimbatore |
|132| ML-1165 | TNAU, Coimbatore |
|133| VGG04-025 | TNAU, Coimbatore |
|134| VGG04-004 | TNAU, Coimbatore |
|135| VGG04-149 | TNAU, Coimbatore |
|136| COGG-954 | TNAU, Coimbatore |
|137| VGG08-002 | TNAU, Coimbatore |
|138| VBN-1 | TNAU, Coimbatore |
|139| VGG-119 | TNAU, Coimbatore |
|140| VC3890-A | TNAU, Coimbatore |
|141| DGGV-4 | UAS, Raichur      |
|142| KPS-1 | UAS, Raichur      |
|   |   |   |
|---|---|---|
| 143 | CGG-973 | UAS, Raichur |
| 144 | CN9-5 | UAS, Raichur |
| 145 | KPS-2 | UAS, Raichur |
| 146 | VC-6173 | UAS, Raichur |
| 147 | VC-6368 | UAS, Raichur |
| 148 | CO-6 | UAS, Raichur |
| 149 | Harsha | UAS, Raichur |
| 150 | PLM-92 | UAS, Bangalore |
| 151 | MH-709 | UAS, Raichur |
| 152 | LGG-460 | RARS, Guntur |
| 153 | KGS-5 | UAS, Raichur |
| 154 | Barimung-4 | UAS, Raichur |
| 155 | AKL-189 | NBPG, Akola |
| 156 | AKL-168 | NBPG, Akola |
| 157 | AKL-218 | NBPG, Akola |
| 158 | AKL-179 | NBPG, Akola |
| 159 | AKL-185 | NBPG, Akola |
| 160 | AKL-163 | NBPG, Akola |
| 161 | COGG-912 | TNAU, Coimbatore |
| 162 | IC-73451 | NBPG, Akola |
| 163 | IC-105690 | NBPG, Akola |
| 164 | IC-73534 | NBPG, Akola |
| 165 | IC-73412 | NBPG, Akola |
| 166 | IC-39605 | NBPG, Akola |
| 167 | IC-73472 | NBPG, Akola |
| 168 | IC-92053 | NBPG, Akola |
| 169 | IC-73779 | NBPG, Akola |
| 170 | IC-73462 | NBPG, Akola |
| 171 | IC-118992 | NBPG, Akola |
| 172 | IC-53783 | NBPG, Akola |
| 173 | IC-73456 | NBPG, Akola |
| 174 | IC-73458 | NBPG, Akola |
| 175 | AKL-105 | NBPG, Akola |
| 176 | AKL-213 | NBPG, Akola |
| 177 | AKL-169 | NBPG, Akola |
| 178 | AKL-220 | NBPG, Akola |
| 179 | AKL-84 | NBPG, Akola |
| 180 | AKL-82 | NBPG, Akola |
| 181 | AKL-97 | NBPG, Akola |
| 182 | AKL-226 | NBPG, Akola |
| 183 | AKL-24 | NBPG, Akola |
| 170 | IC-73462 | NBPG, Akola |
| 171 | IC-118992 | NBPG, Akola |
The standardized range were relatively higher for all the quantitative traits such as; plant height (1.04), cluster per plant (1.34), pods per cluster (0.85), pods per plant (1.87), pod length (0.62), seeds per pod (1.00) test weight (1.10), threshing percentage (0.55), harvest index (1.01), spad chlorophyll meter reading (0.91), leaf water potential (-1.04), proline content (1.15), relative water content (0.93), specific leaf area (1.70) and seed yield per plant (2.56) except for days to 50% flowering (0.48) and days to maturity (0.30).
### Table 3 Summary of augmented ANOVA for grain yield and component traits of germplasm accessions under drought condition

| Sources of Variations     | DF  | DFF  | DM   | PH   | CPP  | PPC  | PPP  | PL   | SPP  | TW   |
|---------------------------|-----|------|------|------|------|------|------|------|------|------|
| **Blocks (b)**            | 4   | 14.74** | 8.18*** | 65.31** | 2.23** | 0.11* | 25.23** | 1.49** | 5.05** | 1.77** |
| **Entries (e)** (Genotypes + Checks) | 204 | 17.10** | 18.01** | 84.47** | 3.60** | 0.51** | 72.94** | 0.75** | 2.70** | 0.35** |
| **Checks**                | 4   | 34.57** | 37.01** | 22.56** | 1.40** | 0.42** | 12.50** | 0.87** | 3.98** | 0.81** |
| **Genotypes**             | 199 | 14.215** | 15.14** | 85.71** | 3.67** | 0.51** | 73.91** | 0.73** | 2.69** | 0.31** |
| **Checks vs Genotypes**   | 1   | 521.64** | 513.06** | 85.01** | 0.16** | 1.45** | 121.60** | 4.52** | 0.03   | 5.42** |
| **Error**                 | 16  | 1.32 | 0.74 | 0.98 | 0.04 | 0.02 | 0.98 | 0.009 | 0.05 | 0.05 |

| Sources of Variations     | DF  | TP    | HI    | SCMR  | LWP   | PC    | RWC   | SLA   | SYPP |
|---------------------------|-----|-------|-------|-------|-------|-------|-------|-------|------|
| **Blocks (b)**            | 4   | 37.12* | 247.54** | 396.55** | 1.17** | 470.90** | 423.68 * | 4067.34 * | 2.11** |
| **Entries (e)** (Genotypes + Checks) | 204 | 37.20** | 54.41 * | 98.71 ** | 2.45 ** | 1707.90** | 425.40 ** | 4283.10 ** | 7.01 ** |
| **Checks**                | 4   | 17.09 | 64.39 * | 24.49 | 0.82 ** | 942.07 ** | 63.06 | 1924.20 | 3.76** |
| **Genotypes**             | 199 | 27.67 * | 53.01 * | 79.58 * | 2.33 ** | 1712.67 ** | 433.68 ** | 4294.15** | 7.10 ** |
| **Checks vs Genotypes**   | 1   | 2014.79 ** | 293.20 ** | 4203.25 ** | 32.57 ** | 3822.09 ** | 227.32 | 11518.68** | 0.42* |
| **Error**                 | 16  | 9.83 | 19.57 | 31.14 | 0.03 | 1.48 | 130.64 | 1339.95 | 0.09 |

*Significant at P =0.05, ** Significant at P=0.01

DFF: Days to 50% flowering, DM: Days to maturity, PH: Plant height (cm), CPP: Cluster plant-1, PPC: Pods cluster-1, DFF: Days to 50% flowering, Pods plant-1, HI: Harvest index (%), SCMR: SPAD Chlorophyll meter reading, SYPP: Seed yield plant-1, LWP: Leaf water potential(Mpa), TP: Threshing %, PC: Proline content (μg g−1), RWC: Relative water content (%)
Table 4: Descriptive statistics for grain yield and its component traits of germplasm accessions under drought condition

| Descriptive | DFF   | DM    | PH    | CPP   | PPC   | PPP   | PL    | SPP   | TW    |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mean        | 41.61 | 69.14 | 37.74 | 5.00  | 3.23  | 16.81 | 5.83  | 6.63  | 3.45  |
| Std. Error  | 0.26  | 0.27  | 0.58  | 0.12  | 0.04  | 0.54  | 0.56  | 0.10  | 0.03  |
| Variance    | 15.93 | 17.37 | 78.13 | 3.32  | 0.47  | 66.93 | 0.71  | 2.55  | 0.35  |
| Minimum     | 33.00 | 60.00 | 19.18 | 1.53  | 1.75  | 4.38  | 4.05  | 3.07  | 1.71  |
| Maximum     | 53.00 | 81.00 | 58.57 | 8.25  | 4.50  | 35.72 | 7.67  | 9.70  | 5.49  |
| Standardized Range | 0.48 | 0.30  | 1.04  | 1.34  | 0.85  | 1.87  | 0.62  | 1.00  | 1.10  |
| Skewness    | 0.38  | 0.30  | -0.31 | -0.11 | -0.18 | 0.23  | 0.08  | -0.13 | -0.04 |
| Kurtosis    | -0.28 | -0.31 | -0.41 | -1.18 | -1.09 | -0.96 | -0.83 | -0.99 | 1.02  |
| GCV (%)     | 8.10  | 5.17  | 10.90 | 17.05 | 20.38 | 118.24 | 6.51 | 10.95 | 14.27 |
| PCV (%)     | 8.55  | 5.32  | 11.21 | 17.50 | 20.94 | 122.14 | 6.71 | 11.46 | 15.93 |
| h² (bs) (%) | 89.79 | 94.63 | 94.53 | 94.77 | 94.72 | 93.70 | 94.13 | 91.34 | 80.21 |
| GAM (5%)    | 15.81 | 10.37 | 5.38  | 40.10 | 40.86 | 61.73 | 34.20 | 29.69 | 33.73 |

| Descriptive | TP    | HI    | SCMR  | LWP   | PC    | RWC   | SLA   | SYPP  |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Mean        | 62.03 | 35.11 | 55.55 | -5.74 | 120.98 | 68.59 | 156.52 | 4.02  |
| Std. Error  | 0.39  | 0.49  | 0.66  | 0.10  | 2.63  | 1.34  | 4.25  | 0.16  |
| Variance    | 35.25 | 55.37 | 99.21 | 2.25  | 1563.92 | 404.32 | 4069.02 | 6.42  |
| Minimum     | 42.89 | 20.52 | 36.59 | -8.14 | 62.70  | 33.63 | 31.96  | 0.74  |
| Maximum     | 76.93 | 55.95 | 87.41 | -2.16 | 201.33 | 97.18 | 298.29 | 11.05 |
| Standardized Range | 0.55 | 1.01  | 0.91  | -1.04 | 1.15  | 0.93  | 1.70  | 2.56  |
| Skewness    | -0.24 | 0.01  | 0.35  | 0.69  | 0.319 | -0.20 | -0.17 | 0.66  |
| Kurtosis    | 0.24  | -1.00 | -0.43 | -0.46 | -1.24 | -1.57 | -0.97 | -0.37 |
| GCV (%)     | 6.58  | 15.84 | 12.25 | 11.81 | 32.13 | 24.26 | 33.56 | 29.45 |
| PCV (%)     | 8.35  | 20.33 | 16.02 | 12.19 | 32.14 | 29.48 | 41.13 | 30.38 |
| h² (bs) (%) | 62.15 | 60.70 | 58.45 | 93.87 | 81.00 | 67.72 | 66.60 | 93.96 |
| GAM (5%)    | 10.70 | 25.42 | 19.29 | 34.77 | 66.15 | 41.13 | 56.43 | 49.67 |

DFF: Days to 50% flowering  DM: Days to maturity  SPP: Seeds per pod  PH: Plant height (cm)
CPP: Cluster plant-1  PC: Proline content(μg g⁻¹)  LWP: Leaf water potential(Mpa)
PL: Pod length (cm)  TW: test weight(g)  RWC: Relative water content (%)
CPP: Pods cluster-1  TP: Threshing % SCMR: SPAD Chlorophyll meter reading
PPC: Pods plant-1  HI: Harvest index (%)  SYPP: Seed yield plant-1
PPP: Pods plant-1  SPP: Seeds per pod  SLA: Specific leaf area

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Higher ranges for plant height and other traits in green gram are reported by Muthuswamy et al., (2019). The magnitude of variation revealed by GCV and PCV in germplasm accessions were low for days to 50% flowering (8.10% and 8.55 % respectively) days to maturity (5.17 % and 5.32 % respectively) threshing percentage (6.58 % and 8.35 % respectively) and pod length (6.51 % and 6.71% respectively). Low GCV and PCV values indicate presence of limited variability for these traits. Moderate GCV and PCV values were observed for plant height (10.90% and 11.21 % respectively), cluster per plant(17.05 % and 17.05% respectively) harvest index (15.84 % and 20.33 % respectively), spad chlorophyll meter reading (12.52 % and 16.02 % respectively) and leaf water potential (11.81 % and 12.19 % respectively).

Higher standardized range (1.87) resulted in higher GCV and PCV values for pods per plant(118.24% and 122.14% respectively). Similarly higher GCV and PCV values were observed for proline content (31.13% and 32.14% respectively), relative water content (24.26% and 29.48 % respectively), specific leaf area (33.56 % and 41.13 % respectively) and seed yield per plant (29.45% and 30.38% respectively). Muthuswamy et al., (2019) and Tejbir et al., (2009)have reported similar findings on GCV and PCV estimates.

Heritability is a quantitative measure which provides information about the relative contribution of genetic factors to the phenotypic expression. The estimates of genetic advance may be biased if phenotypic variance contains a fraction of genetic variance due to non-additive effects (Hanson et al., 1956).According to Johnson et al., (1955), heritability estimates along with genetic gain would be more useful and informative in predicting effectiveness of selection. Hence it is essential to consider the predicted genetic advance along with heritability estimates as a tool in selection for increased efficiency. Germplasm accessions exhibited relatively higher heritability for all the quantitative traits; days to 50% flowering (89.79 %), days to maturity (94.63 %), plant height (94.53 %), cluster per plant(94.77 %), pods per cluster(94.72 %), pods per plant(93.70 %), pod length (94.13 %), seeds per pod (91.34%) test weight (80.21 %), threshing percentage (62.15 %), harvest index (60.70 %), spad chlorophyll meter reading (58.45 %), leaf water potential (99.96 %), proline content (81.00 %), relative water content (67.72 %), specific leaf area (66.60 %) and seed yield per plant(93.96%) . Kate et al., (2017) has reported high heritability coupled with moderate genetic advance for the traits; plant height, days to maturity, pods per plant, protein content, and grain yield per plant in green gram.

Higher expected GAM coupled with high heritability of grain yield and its component traits like primary branches per plant(187.76) pods per plant(97.68), cluster per plant(74.54), seeds per pod (48.06) and pods per cluster(40.86). The higher GAM was also recorded for physiological traits governing drought tolerance such as leaf water potential (53.38), proline content (66.15), relative water content (41.13) and specific leaf area (56.43). Kousar et al., (2007) also reported high heritability coupled with genetic advance for pods per plant and plant height. Similar findings were reported by Gadakh et al., (2013) and Hemavathy et al., (2014)

The study revealed that germplasm accessions differed greatly for phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense) and genetic advancement for all the agronomic and physiological traits under drought condition.
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