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# Evaluation of green gram genotypes for drought tolerance by PEG (polyethylene glycol) induced drought stress at seedling stage

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## ABSTRACT

Drought stress is one of the major constraints for pulse production which negatively affecting its growth and production. Screening and selection of desirable genotypes for drought tolerance is the first and foremost important step in pulse breeding program. In green gram standardization for moisture stress was done under laboratory conditions using various concentration of PEG 6000 and 50% seedling mortality was observed at 0.5 MPa of moisture stress. Using this level of moisture stress 108 green gram genotypes were screened for their drought tolerance at seedling level and the following parameters *viz*., germination percentage, promptness index, radicle length, root length stress index, germination stress index and seed vigour were recorded. Observations revealed that the following green gram genotypes COGG 1332, VGG 16069, VGG 17003, VGG 17004, VGG 17009, VGG 17019 and VGG 17045 were found highly tolerant to moisture stress at seedling stage.

**Key words:** Drought, Genotypes, Germination, Green gram, PEG-6000, Seedling.

## INTRODUCTION

Globally, the agricultural productivity is affected by abiotic and biotic stresses; in particular abiotic stresses adversely affect the plant growth and productivity (Craita and Gerats, 2013). Drought stress is one of the main abiotic stresses that limits the crop productivity in the arid and semi-arid region due to limitation of water sources and irregular rainfall during crop growth season (Eck, 1986). Drought damage within the plants begins primarily with disruption of osmotic balance, in association with metabolic and physiological disorders (Hasanuzzaman and Fujita, 2011). Due to climate change it is predicted that in the future drought will occur more frequent and severe and it will be a major constraint for crop production affecting the global crop yields (Cutforth *et al*., 2007). Green gram is one of the important summer season leguminous crop in India with high nutritional value, short growing season and soil fertility restoration by biological nitrogen fixation. It is a good protein source (~23%) with high digestibility, it contain very low levels of oligosaccharides (Ihsan *et al.,* 2013). Green gram accounts about 65 and 54 % of world acreage and production, among that India is the largest producer and consumer in the world. It thrives well in drought prone areas, it is cultivated in more than 6 million ha in the tropical regions of the world (Nair *et al*., 2012); when compared to other legumes it requires less water for the crop growth, however a variability in drought tolerance among the green gram genotypes is present. Among the growth stages seed germination and early seedling growth stages are considered critical because it indirectly determines the crop yield especially under arid and semi-arid region (Agrawal, 1980). Therefore, there is a need to evaluate the genotypes for drought tolerance which could with stand limited soil moisture and produce better yield.

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The screening of desirable genotypes is important for successful breeding to develop the elite lines having drought tolerance capacity (Feller, 2006). The water potential can be altered by the use of high molecular weight osmotic substance, like polyethylene glycol (PEG 6000) which is often used to control water potential in seed germination studies (Hardegree and Emmerich, 1990). Among various traits, osmotic adjustment is one of the major responses exhibited by crop plants under water deficit condition (Hsiao, 1973). The genotypes which perform better under lower water potential enable the identification of plant genetic resources suitable for growing under water deficit condition (Kaur *et al*., 2017). The objective of this investigation is to evaluate the green gram genotypes that can tolerate the moisture stress at germination and seedling stages; thereby it can be used as genetic materials in crop improvement programmes to develop climate smart green gram varieties.

## MATERIALS AND METHODS

### Plant materials and stress treatments

### Standardization of drought stress using polyethylene glycol (PEG 6000)

The green gram varieties Vamban 1, VBN(Gg) 2, VBN(Gg) 3 and CO 8 were used to standardize the drought stress using polyethylene glycol (PEG 6000). Healthy and seeds of uniform size were surface sterilized with 0.1% Mercuric chloride ($HgCl_2$) for 2-3 min and then washed thoroughly with distilled water. Sterilized (20) seeds were sown in petridishes containing moistened blotting paper with various water potential *viz*., 0.0 (control), -0.4, -0.5, -0.6 and -0.7 MPa PEG 6000 with five replication were maintained for each treatment. The emergence of 2mm radicle was set as the criteria for germination (Kaur *et al*., 2017). Numbers of seeds germinated were counted on alternate day's from day-2 to day-8 after sowing to determine the germination percentage. Seedling growth parameters such as plumule length and radicle length were recorded on 8$^{th}$ day after

**Table 1:** Details of the green gram genotypes used in this study.

| Green gram genotypes | Green gram genotypes | Green gram genotypes | Green gram genotypes |
|---|---|---|---|
| ADGG13009 | VGG 15030 | VGG 16065 | VGG 17022 |
| AGG35 | VGG 15031 | VGG 16066 | VGG 17023 |
| CO6 | VGG 15032 | VGG 16067 | VGG 17024 |
| CO8 | VGG 15035 | VGG 16068 | VGG 17025 |
| COGG1319 | VGG 15036 | VGG 16069 | VGG 17026 |
| COGG1332 | VGG 15038 | VGG 16070 | VGG 17027 |
| COGG1339 | VGG 15040 | VGG 17001 | VGG 17028 |
| LGG607 | VGG 16003 | VGG 17002 | VGG 17029 |
| MGG385 | VGG 16005 | VGG 17003 | VGG 17030 |
| MGG387 | VGG 16006 | VGG 17004 | VGG 17032 |
| NBL722 | VGG 16008 | VGG 17005 | VGG 17034 |
| OBGG56 | VGG 16016 | VGG 17006 | VGG 17035 |
| OBGG57 | VGG 16026 | VGG 17007 | VGG 17036 |
| OBGG58 | VGG 16027 | VGG 17008 | VGG 17037 |
| PUSA9072 | VGG16028 | VGG 17009 | VGG 17038 |
| Samrat | VGG 16029 | VGG 17010 | VGG 17039 |
| TARM1 | VGG 16035 | VGG 17011 | VGG 17040 |
| TMGG11035 | VGG 16036 | VGG 17012 | VGG 17041 |
| Vamban1 | VGG 16046 | VGG 17013 | VGG 17042 |
| VBN(Gg)2 | VGG 16054 | VGG 17014 | VGG 17043 |
| VBN(Gg)3 | VGG 16055 | VGG 17015 | VGG 17045 |
| VGG 05009 | VGG 16057 | VGG 17016 | VGG 17046 |
| VGG 10008 | VGG 16058 | VGG 17017 | VGG 17047 |
| VGG 15013 | VGG 16061 | VGG 17018 | VGG 17048 |
| VGG 15015 | VGG 16062 | VGG 17019 | VGG 17049 |
| VGG 15016 | VGG 16063 | VGG 17020 | VGG 17050 |
| VGG 15029 | VGG 16064 | VGG 17021 | VMGG12005 |

**Table 2:** Germination percentage (%) and promptness index of green gram varieties under control and different levels of water potential.

| Genotypes | Germination percentage (%) | | | | | Promptness index | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | -0.4 Mpa | -0.5 Mpa | -0.6 Mpa | -0.7 Mpa | Control | -0.4 Mpa | -0.5 Mpa | -0.6 Mpa | -0.7 Mpa |
| Vamban 1 | 100.00 | 81.28 | 29.00 | 11.64 | 4.67 | 31.55 | 20.60 | 4.00 | 1.85 | 0.25 |
| VBN(Gg)2 | 100.00 | 90.94 | 41.52 | 11.21 | 12.21 | 49.50 | 44.60 | 11.65 | 2.40 | 0.55 |
| VBN(Gg)3 | 100.00 | 86.49 | 44.52 | 12.10 | 10.00 | 48.90 | 24.60 | 6.70 | 2.00 | 0.80 |
| CO8 | 100.00 | 70.36 | 4.21 | 1.11 | - | 47.80 | 17.80 | 0.90 | 0.30 | 0.00 |
| **Mean** | **100.00** | **82.26** | **29.81** | **9.01** | **6.72** | **44.43** | **26.90** | **5.81** | **1.63** | **0.40** |
| Level of | | G | T | G×T | | | G | T | G×T | |
| significance | | *** | *** | *** | | | *** | *** | *** | |
| SEm | | 2.20 | 2.46 | 4.93 | | | 0.78 | 0.87 | 1.74 | |
| CV (%) | | | 17.09 | | | | | 17.36 | | |

G- Genotype; T- Treatment; Significant differences are indicated *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; ns- non-significant.

sowing in randomly selected seedlings. Germination percentage, Promptness Index (PI), Germination stress index (GSI), Plant height stress Index (PHSI), Root length stress index (RLSI) and Seed vigour (SV) were measured using the following formula.

PI (%) = nd2 (1.00) +nd4 (0.75) +nd6 (0.5) +nd8 (0.25)

Where,

PI is promptness index, nd is the number of seeds germinated on the day of observation (George, 1967); GSI(%) = [PI of stressed seeds / PI control seeds] × 100 (Maiti *et al*., 1994) ; RLSI(%) = [Root length stressed plant / Root length of control plants] × 100; SV(%) = Germination percentage × seedling length. PEG 6000 concentration of -0.5 MPa that induce 50% seedling mortality was the stress level for screening the green gram genotypes.

**Screening of the green gram genotypes for drought stress tolerance at seedling stage**

A set of 108 green gram genotypes (Table 1) were used for this study to identify the tolerant genotypes. Surface sterilized green gram seeds were sown in petridishes containing blotting paper moistened with water 0.0 Mpa and -0.5 MPa of PEG 6000 solution. Three replications with 20 seeds in each were maintained. Plumule length and radicle length of seedlings were recorded on 8$^{th}$ day after sowing in ten randomly selected seedlings in each replication.

**Statistical analysis**

The experimental design was factorial experiment under completely randomized design (FCRD) with five replications for standardization of drought stress and three replications for screening the set of 108 green gram genotypes. Statistical analysis was performed using Statistical Tool for Agricultural Research (STAR) version 2.0.1.Principal component analysis (PCA) was performed using ClustVis.

## RESULTS AND DISCUSSION

A standardization experiment was set up with the green gram varieties Vamban1, VBN (Gg) 2, VBN (Gg) 3 and CO 8 to determine the stress level at which the green gram genotypes collection could be screened. These varieties were germinated at different water potential *viz*., 0, -0.4, -0.5, -0.6 and -0.7 MPa and seedling growth characteristics such as germination percentage, PI, radicle length, RLSI, GSI and seed vigour were recorded. A significant decrease in the germination percentage 50% mortality was observed at -0.5MPa at this concentration the germination percentage was higher (44.52%) in VBN (Gg) 3 and lower (4.21%) in CO 8 (Table 2). The difference in germination rate of genotypes at moisture stress condition would be helpful to identify the tolerant genotype to drought condition (Kaur *et al*., 2017; Dutta and Bera, 2008). The PI, plumule length, radicle length, seed vigour, GSI and RLSI of the green gram varieties at different water potential were given in Table 2, 3 and 4. The PI was higher (11.65) in VBN(Gg) 2 and lower (0.90) in CO 8 at -0.5MPa. The germination percentage, PI,

**Table 3:** Radicle length (cm), plumule length (cm) and seed vigour of green gram varieties under control and different levels of water potential.

| Genotypes | Radicle length (cm) | | | | | Plumule length (cm) | | | | | Seed vigour | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Control | -0.4 Mpa | -0.5 Mpa | -0.6 Mpa | -0.7 Mpa | Control | -0.4 Mpa | -0.5 Mpa | -0.6 Mpa | -0.7 Mpa | Control | -0.4 Mpa | -0.5 Mpa | -0.6 Mpa | -0.7 Mpa |
| Vamban 1 | 6.12 | 2.80 | 0.82 | 0.52 | 0.06 | 8.60 | 0.28 | - | - | - | 1472.00 | 242.30 | 21.96 | 5.02 | 0.75 |
| VBN(Gg) 2 | 7.30 | 3.40 | 1.86 | 0.48 | 0.42 | 10.54 | 0.42 | 0.10 | - | - | 1784.00 | 348.66 | 77.94 | 5.18 | 5.60 |
| VBN(Gg) 3 | 7.38 | 3.96 | 1.56 | 0.40 | 0.24 | 8.80 | 1.18 | 0.14 | - | - | 1618.00 | 440.23 | 75.95 | 6.14 | 2.90 |
| CO8 | 4.74 | 4.18 | 0.34 | 0.04 | - | 8.00 | 0.58 | - | - | - | 1274.00 | 335.63 | 1.78 | 0.22 | - |
| **Mean** | **6.39** | **3.59** | **1.15** | **0.36** | **0.24** | **8.99** | **0.62** | **0.12** | - | - | **1537.00** | **341.71** | **44.41** | **4.14** | **2.31** |
| Level of significance | G | T | G×T | | | | G | T | G×T | | | G | T | G×T | |
| | ** | *** | * | | | | ns | *** | * | | | ** | *** | ** | |
| SEm | 0.26 | 0.29 | 0.58 | | | | 0.21 | 0.24 | 0.49 | | | 38.81 | 43.40 | 86.79 | |
| CV (%) | | 39.95 | | | | | | 40.22 | | | | | 35.56 | | |

G- Genotype; T- Treatment; Significant differences are indicated *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$; ns- non-significant.

**Table 4:** Germination stress index and root length stress index of green gram varieties under control and different levels of water potential.

| Genotypes | Germination stress index | | | | Root length stress index | | | |
|---|---|---|---|---|---|---|---|---|
| | -0.4 Mpa | -0.5 Mpa | -0.6 Mpa | -0.7 Mpa | -0.4 Mpa | -0.5 Mpa | -0.6 Mpa | -0.7 Mpa |
| Vamban 1 | 64.70 | 18.10 | 67.94 | 13.33 | 44.91 | 13.37 | 8.40 | 0.96 |
| VBN(Gg) 2 | 90.14 | 26.64 | 18.85 | 40.00 | 50.35 | 27.74 | 7.08 | 6.52 |
| VBN(Gg) 3 | 50.27 | 28.00 | 44.04 | 26.31 | 57.26 | 21.98 | 5.32 | 3.38 |
| CO8 | 37.72 | 4.37 | 20.00 | - | 90.15 | 7.01 | 0.88 | - |
| **Mean** | **60.71** | **19.28** | **37.71** | **19.91** | **60.67** | **17.53** | **5.42** | **2.72** |
| Level of | G | T | G×T | | G | T | G×T | |
| significance | ** | *** | ns | | ns | *** | *** | |
| SEm | 8.85 | 8.85 | 17.71 | | 3.96 | 3.96 | 7.91 | |
| CV (%) | | 81.38 | | | | 57.94 | | |

G- Genotype; T- Treatment; Significant differences are indicated *, $P < 0.05$;
**, $P < 0.01$; ***, $P < 0.001$; ns- non-significant.

**Table 5:** Germination percentage (%), promptness index, radicle length (cm), plumule length (cm), seed vigour, germination stress index and root length stress index of different green gram genotypes under control and -0.5 MPa PEG 6000.

| Genotypes | Germination percentage (%) | | Promptness index | | Radicle length (cm) | | Seed vigour | | Germination stress index | Root length stress index |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | -0.5 MPa | Control | -0.5 MPa | Control | -0.5 MPa | Control | -0.5 MPa | -0.5 MPa | -0.5 MPa |
| ADGG13009 | 100.00 | 21.73 | 43.67 | 8.33 | 8.00 | 0.83 | 1860.00 | 19.04 | 19.10 | 10.48 |
| AGG35 | 100.00 | 39.16 | 43.17 | 14.50 | 4.57 | 2.20 | 1243.33 | 87.04 | 33.63 | 49.81 |
| CO6 | 100.00 | 27.63 | 48.33 | 12.17 | 5.30 | 1.60 | 1616.67 | 42.94 | 25.18 | 30.03 |
| CO8 | 100.00 | 7.12 | 46.92 | 1.83 | 5.17 | 0.60 | 1480.00 | 4.07 | 3.95 | 11.64 |
| COGG1319 | 100.00 | 41.14 | 44.42 | 14.42 | 4.13 | 2.93 | 1283.33 | 124.87 | 32.56 | 71.98 |
| **COGG1332** | **100.00** | **57.30** | **42.67** | **25.17** | **5.50** | **2.40** | **1166.67** | **136.88** | **59.48** | **44.18** |
| COGG1339 | 100.00 | 20.40 | 46.92 | 7.17 | 6.00 | 0.53 | 1436.67 | 10.67 | 15.22 | 8.81 |
| LGG607 | 100.00 | 12.30 | 46.33 | 5.25 | 6.00 | 0.70 | 1510.00 | 8.77 | 11.30 | 11.63 |
| MGG385 | 100.00 | 26.91 | 42.75 | 9.92 | 7.77 | 1.67 | 1796.67 | 44.42 | 23.19 | 22.51 |
| MGG387 | 100.00 | - | 46.67 | - | 4.07 | - | 910.00 | - | - | - |
| NBL722 | 100.00 | - | 46.08 | - | 4.33 | - | 1033.33 | - | - | - |
| OBGG56 | 100.00 | - | 46.92 | - | 8.50 | - | 1760.00 | - | - | - |
| OBGG57 | 100.00 | - | 49.17 | - | 5.43 | - | 1243.33 | - | - | - |
| OBGG58 | 100.00 | - | 42.75 | - | 5.87 | - | 1326.67 | - | - | - |
| PUSA9072 | 100.00 | 48.33 | 49.42 | 26.00 | 3.77 | 0.90 | 1093.33 | 43.67 | 52.56 | 24.02 |
| Samrat | 100.00 | 34.04 | 45.08 | 10.50 | 5.43 | 1.57 | 1520.00 | 54.10 | 23.37 | 35.28 |
| TARM1 | 100.00 | 49.12 | 47.50 | 21.00 | 6.50 | 4.90 | 1430.00 | 240.79 | 44.14 | 75.46 |
| TMGG11035 | 100.00 | 35.95 | 43.58 | 14.17 | 5.93 | 1.30 | 1493.33 | 46.47 | 32.49 | 21.91 |
| Vamban1 | 100.00 | 17.49 | 39.33 | 2.17 | 6.10 | 0.33 | 1130.00 | 5.63 | 5.56 | 5.30 |
| VBN(Gg)2 | 100.00 | 34.41 | 38.83 | 9.42 | 4.57 | 1.13 | 1473.33 | 40.97 | 24.12 | 25.74 |
| VBN(Gg)3 | 100.00 | 39.81 | 47.75 | 7.17 | 6.50 | 0.60 | 1776.67 | 23.91 | 14.97 | 9.25 |
| VGG 05009 | 100.00 | 12.66 | 38.83 | 3.83 | 4.90 | 1.43 | 1506.67 | 17.55 | 9.90 | 30.80 |
| VGG 10008 | 100.00 | 42.36 | 46.92 | 5.00 | 8.00 | 1.67 | 1686.67 | 72.39 | 10.73 | 22.78 |
| VGG 15013 | 100.00 | 11.68 | 42.50 | 1.50 | 9.57 | 1.97 | 2150.00 | 23.53 | 3.50 | 20.73 |
| VGG 15015 | 100.00 | 14.06 | 45.17 | 2.00 | 6.73 | 1.37 | 1536.67 | 19.08 | 4.42 | 21.79 |
| VGG 15016 | 100.00 | 24.52 | 46.92 | 5.25 | 6.57 | 2.60 | 1500.00 | 65.50 | 11.11 | 41.20 |
| VGG 15029 | 100.00 | 48.44 | 40.83 | 11.42 | 6.97 | 2.13 | 2003.33 | 104.40 | 28.28 | 32.21 |
| VGG 15030 | 100.00 | 9.94 | 35.50 | 1.83 | 10.27 | 3.03 | 2083.33 | 29.13 | 5.16 | 30.33 |
| VGG 15031 | 100.00 | 13.40 | 42.17 | 3.50 | 9.23 | 1.83 | 1810.00 | 25.00 | 8.23 | 21.06 |
| VGG 15032 | 100.00 | 15.63 | 46.92 | 3.42 | 7.07 | 1.27 | 1970.00 | 20.70 | 7.07 | 17.73 |

**Table 5: Continue...**

**Table 5: Continue...**

| Genotypes | Germination percentage (%) | | Promptness index | | Radicle length (cm) | | Seed vigour | | Germination stress index | Root length stress index |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | -0.5 MPa | Control | -0.5 MPa | Control | -0.5 MPa | Control | -0.5 MPa | -0.5 MPa | -0.5 MPa |
| VGG 15035 | 100.00 | 12.02 | 45.42 | 1.75 | 7.93 | 1.10 | 2100.00 | 12.77 | 3.82 | 13.87 |
| VGG 15036 | 100.00 | 39.65 | 47.75 | 5.17 | 5.80 | 0.93 | 1273.33 | 37.30 | 10.74 | 16.28 |
| VGG 15038 | 100.00 | 1.96 | 42.50 | 0.83 | 6.50 | 0.57 | 1593.33 | 0.98 | 1.96 | 9.14 |
| VGG 15040 | 100.00 | 7.53 | 45.00 | 3.33 | 5.57 | 1.10 | 1403.33 | 8.07 | 7.38 | 20.05 |
| VGG 16003 | 100.00 | - | 49.17 | - | 8.33 | - | 1850.00 | - | - | - |
| VGG 16005 | 100.00 | 42.37 | 49.17 | 19.08 | 8.77 | 0.50 | 1600.00 | 21.28 | 38.81 | 5.84 |
| VGG 16006 | 100.00 | - | 45.25 | - | 4.77 | - | 1353.33 | - | - | - |
| VGG 16008 | 100.00 | 19.06 | 43.58 | 4.83 | 8.37 | 1.10 | 1506.67 | 22.85 | 11.18 | 13.30 |
| VGG 16016 | 100.00 | 28.22 | 47.50 | 11.00 | 7.37 | 2.50 | 1653.33 | 70.58 | 23.30 | 34.42 |
| VGG 16026 | 100.00 | 15.00 | 49.42 | 5.75 | 6.13 | 0.50 | 1383.33 | 7.67 | 11.64 | 8.35 |
| VGG 16027 | 100.00 | - | 44.08 | - | 7.40 | - | 1500.00 | - | - | - |
| VGG 16028 | 100.00 | 21.73 | 45.25 | 8.25 | 8.50 | 2.87 | 1363.33 | 64.59 | 18.02 | 34.92 |
| VGG 16029 | 100.00 | - | 43.83 | - | 7.13 | - | 1716.67 | - | - | - |
| VGG 16035 | 100.00 | - | 49.17 | - | 9.23 | - | 1840.00 | - | - | - |
| VGG 16036 | 100.00 | 23.77 | 49.17 | 9.33 | 5.73 | 2.10 | 1273.33 | 49.96 | 19.04 | 40.16 |
| VGG 16046 | 100.00 | 1.75 | 45.25 | 0.25 | 5.20 | 1.37 | 1166.67 | 3.68 | 0.53 | 26.39 |
| VGG 16054 | 100.00 | 27.02 | 46.25 | 9.83 | 8.60 | 1.23 | 1876.67 | 32.13 | 21.29 | 15.19 |
| VGG 16055 | 100.00 | - | 43.58 | - | 5.70 | - | 1256.67 | - | - | - |
| VGG 16057 | 100.00 | 5.66 | 44.17 | 1.92 | 6.23 | 2.30 | 1323.33 | 15.40 | 4.37 | 36.56 |
| VGG 16058 | 100.00 | - | 47.50 | - | 6.17 | - | 1086.67 | - | - | - |
| VGG 16061 | 100.00 | 28.22 | 46.33 | 11.00 | 3.50 | 2.20 | 1173.33 | 62.87 | 23.89 | 67.63 |
| VGG 16062 | 100.00 | 37.19 | 48.00 | 14.25 | 6.03 | 2.10 | 1130.00 | 78.11 | 29.76 | 35.19 |
| VGG 16063 | 100.00 | 23.33 | 50.00 | 9.33 | 6.37 | 0.63 | 1353.33 | 14.50 | 18.67 | 9.87 |
| VGG 16064 | 100.00 | 9.16 | 43.50 | 3.58 | 5.17 | 1.00 | 983.33 | 9.55 | 8.29 | 21.04 |
| VGG 16065 | 100.00 | 20.08 | 43.50 | 6.25 | 3.83 | 1.13 | 1060.00 | 22.95 | 14.34 | 32.57 |
| VGG 16066 | 100.00 | 34.43 | 44.75 | 12.33 | 7.87 | 1.83 | 1616.67 | 64.05 | 27.44 | 23.29 |
| VGG 16067 | 100.00 | 23.68 | 46.83 | 9.33 | 3.90 | 1.47 | 1140.00 | 34.56 | 19.98 | 38.80 |
| VGG 16068 | 100.00 | 33.67 | 46.92 | 9.42 | 5.13 | 2.57 | 1293.33 | 88.44 | 20.28 | 55.77 |
| **VGG 16069** | **100.00** | **62.28** | **45.58** | **25.83** | **6.50** | **1.77** | **896.67** | **107.54** | **56.72** | **27.17** |
| VGG 16070 | 100.00 | 20.79 | 46.00 | 5.75 | 3.23 | 1.83 | 1456.67 | 36.21 | 12.53 | 61.68 |
| VGG 17001 | 100.00 | 42.59 | 45.83 | 12.92 | 7.17 | 0.80 | 1676.67 | 34.63 | 27.85 | 11.08 |
| VGG 17002 | 100.00 | 45.07 | 41.17 | 18.83 | 7.20 | 2.30 | 1380.00 | 103.76 | 45.78 | 32.30 |
| **VGG 17003** | **100.00** | **76.16** | **45.25** | **30.75** | **6.97** | **2.43** | **1550.00** | **183.11** | **67.36** | **35.53** |
| **VGG 17004** | **100.00** | **69.50** | **43.25** | **25.58** | **5.07** | **2.47** | **1350.00** | **167.54** | **58.32** | **48.77** |
| VGG 17005 | 100.00 | 21.67 | 44.67 | 6.50 | 5.30 | 1.17 | 1433.33 | 25.76 | 14.32 | 21.75 |
| VGG 17006 | 100.00 | 49.02 | 47.50 | 21.00 | 6.53 | 1.50 | 1493.33 | 73.73 | 44.15 | 22.88 |
| VGG 17007 | 100.00 | 38.89 | 43.75 | 16.17 | 6.70 | 1.77 | 1473.33 | 69.44 | 37.02 | 26.58 |
| VGG 17008 | 100.00 | - | 47.75 | - | 6.73 | - | 1056.67 | - | - | - |
| **VGG 17009** | **100.00** | **61.57** | **45.17** | **27.42** | **8.43** | **3.33** | **1756.67** | **200.72** | **61.68** | **39.55** |
| VGG 17010 | 100.00 | 7.31 | 42.58 | 2.75 | 5.83 | 1.13 | 1453.33 | 4.16 | 4.54 | 19.71 |
| VGG 17011 | 100.00 | 7.52 | 43.58 | 2.75 | 4.90 | 1.53 | 1430.00 | 11.84 | 6.32 | 32.08 |
| VGG 17012 | 100.00 | 8.88 | 45.00 | 3.17 | 6.03 | 0.40 | 1503.33 | 3.57 | 7.05 | 6.66 |
| VGG 17013 | 100.00 | 24.33 | 43.17 | 8.42 | 8.67 | 0.50 | 1850.00 | 11.76 | 19.65 | 5.81 |
| VGG 17014 | 100.00 | 12.59 | 45.50 | 4.67 | 8.60 | 3.70 | 1566.67 | 47.22 | 10.43 | 44.34 |
| VGG 17015 | 100.00 | 19.88 | 44.25 | 4.33 | 5.17 | 1.07 | 1376.67 | 21.64 | 9.87 | 21.09 |
| VGG 17016 | 100.00 | 35.57 | 44.67 | 22.50 | 5.70 | 1.50 | 1333.33 | 52.66 | 50.28 | 26.48 |
| VGG 17017 | 100.00 | 8.68 | 46.58 | 1.25 | 4.03 | - | 993.33 | - | 2.70 | - |

**Table 5: Continue...**

**Table 5: Continue...**

| Genotypes | Germination percentage (%) | | Promptness index | | Radicle length (cm) | | Seed vigour | | Germination stress index | Root length stress index |
|---|---|---|---|---|---|---|---|---|---|---|
| | Control | -0.5 MPa | Control | -0.5 MPa | Control | -0.5 MPa | Control | -0.5 MPa | -0.5 MPa | -0.5 MPa |
| VGG 17018 | 100.00 | 36.53 | 45.17 | 10.42 | 4.87 | 1.63 | 1373.33 | 59.54 | 23.15 | 33.77 |
| **VGG 17019** | **100.00** | **60.89** | **43.83** | **11.17** | **5.73** | **2.00** | **1366.67** | **122.95** | **25.28** | **34.99** |
| VGG 17020 | 100.00 | 15.00 | 50.00 | 5.17 | 4.00 | 0.30 | 940.00 | 4.00 | 10.33 | 7.72 |
| VGG 17021 | 100.00 | - | 44.33 | - | 6.77 | - | 993.33 | - | - | - |
| VGG 17022 | 100.00 | 3.61 | 43.25 | 1.67 | 4.50 | 0.87 | 983.33 | 3.39 | 3.83 | 20.16 |
| VGG 17023 | 100.00 | 7.21 | 45.50 | 2.75 | 7.50 | 0.97 | 1206.67 | 6.84 | 6.06 | 12.89 |
| VGG 17024 | 100.00 | 5.57 | 43.25 | 2.50 | 5.83 | 0.23 | 1466.67 | 1.28 | 5.79 | 4.05 |
| VGG 17025 | 100.00 | - | 49.17 | - | 10.77 | - | 1760.00 | - | - | - |
| VGG 17026 | 100.00 | 12.22 | 47.75 | 4.08 | 6.43 | 0.73 | 1530.00 | 8.00 | 8.67 | 11.46 |
| VGG 17027 | 100.00 | 17.49 | 47.50 | 6.00 | 4.13 | 0.53 | 793.33 | 9.74 | 12.56 | 12.02 |
| VGG 17028 | 100.00 | 37.66 | 45.83 | 17.67 | 7.10 | 1.47 | 1556.67 | 57.05 | 38.62 | 22.22 |
| VGG 17029 | 100.00 | 17.90 | 46.67 | 6.00 | 8.13 | 1.20 | 1833.33 | 21.73 | 12.97 | 14.76 |
| VGG 17030 | 100.00 | 25.35 | 48.58 | 10.17 | 6.27 | 2.10 | 1370.00 | 53.37 | 20.93 | 34.58 |
| VGG 17032 | 100.00 | - | 42.67 | - | 6.90 | - | 1490.00 | - | - | - |
| VGG 17034 | 100.00 | 16.37 | 44.67 | 6.92 | 8.10 | 1.43 | 1710.00 | 23.98 | 15.60 | 18.13 |
| VGG 17035 | 100.00 | 33.77 | 48.58 | 9.67 | 4.83 | 0.80 | 1166.67 | 27.60 | 19.78 | 16.45 |
| VGG 17036 | 100.00 | 10.82 | 45.17 | 8.83 | 9.27 | 0.40 | 1673.33 | 5.01 | 19.57 | 4.38 |
| VGG 17037 | 100.00 | 17.10 | 44.17 | 6.92 | 6.47 | 1.20 | 1556.67 | 21.08 | 15.81 | 19.92 |
| VGG 17038 | 100.00 | - | 50.00 | - | 8.50 | - | 1880.00 | - | - | - |
| VGG 17039 | 100.00 | 6.96 | 47.50 | 2.17 | 8.63 | 1.67 | 1680.00 | 11.70 | 4.42 | 19.49 |
| VGG 17040 | 100.00 | 16.67 | 50.00 | 7.17 | 5.73 | 1.60 | 1620.00 | 26.83 | 14.33 | 28.12 |
| VGG 17041 | 100.00 | 20.07 | 44.17 | 8.50 | 5.70 | 0.67 | 1386.67 | 13.14 | 19.19 | 11.70 |
| VGG 17042 | 100.00 | 20.44 | 49.17 | 7.67 | 4.60 | 0.37 | 1230.00 | 7.72 | 15.71 | 7.85 |
| VGG 17043 | 100.00 | 28.28 | 46.67 | 11.58 | 4.20 | 0.37 | 1043.33 | 10.62 | 24.51 | 9.07 |
| **VGG 17045** | **100.00** | **53.33** | **50.00** | **23.75** | **10.53** | **2.27** | **2046.67** | **120.33** | **47.50** | **21.48** |
| VGG 17046 | 100.00 | 33.95 | 49.17 | 15.50 | 7.33 | 2.70 | 1543.33 | 90.95 | 31.55 | 37.23 |
| VGG 17047 | 100.00 | 24.12 | 47.17 | 8.17 | 5.90 | 2.70 | 1180.00 | 64.78 | 17.32 | 45.77 |
| VGG 17048 | 100.00 | 12.48 | 44.92 | 4.08 | 6.70 | 0.40 | 1308.13 | 4.68 | 9.04 | 5.97 |
| VGG 17049 | 100.00 | - | 48.33 | - | 7.63 | - | 1850.00 | - | - | - |
| VGG 17050 | 100.00 | - | 46.92 | - | 7.00 | - | 1630.00 | - | - | - |
| VMGG12005 | 100.00 | 40.94 | 42.83 | 18.83 | 4.77 | 1.90 | 1243.33 | 79.71 | 44.43 | 39.87 |
| **Mean** | **100.00** | **21.74** | **45.56** | **7.79** | **6.42** | **1.23** | **1455.01** | **37.45** | **17.11** | **20.67** |
| Level of | G T G×T | | G T G×T | | G T G×T | | G T G×T | | G | G |
| significance | *** *** *** | | *** *** *** | | *** *** *** | | *** *** *** | | *** | *** |
| SEmCV (%) | 2.73 0.37 3.86 | | 1.58 0.22 2.24 | | 0.45 0.06 0.642 | | 63.77 8.68 90.18 | | 5.67 | 6.68 |
| | 7.76 | | 10.28 | | 20.53 | | 14.80 | | 40.60 | 39.59 |

G- Genotype; T- Treatment; Significant differences are indicated *, $P < 0.05$;

**, $P < 0.01$; ***, $P < 0.001$; ns- non-significant (Genotypes which are bold - showed higher germination percentage).

plumule and radicle length, seed vigour, GSI and RLSI were highly decreased at lower water potential, the reduction of seedling length was reduced gradually in the successive reduced water potential. The reduction in plumule length was found to be higher as compared to that of reduction in radicle length under moisture stress condition (Dutta and Bera, 2008). Therefore, the drought stress affects the plant growth and development especially during seedling stage (Kaur *et al*., 2017).

Based on the standardization, drought stress was imposed on the green gram genotypes at -0.5 MPa and distilled water was used for control. The same seedling growth characteristics were recorded on 8$^{th}$ day after sowing. The germination rate of green gram genotypes was observed at 0.0 (control) and -0.5 MPa (Table 5). The green gram genotypes VGG 17003 (76.16%), VGG 17004 (69.50%), VGG 16069 (62.28%), VGG 17009 (61.57%), VGG 17019 (60.89%), COGG1332 (57.30%), VGG 17045 (53.33%)

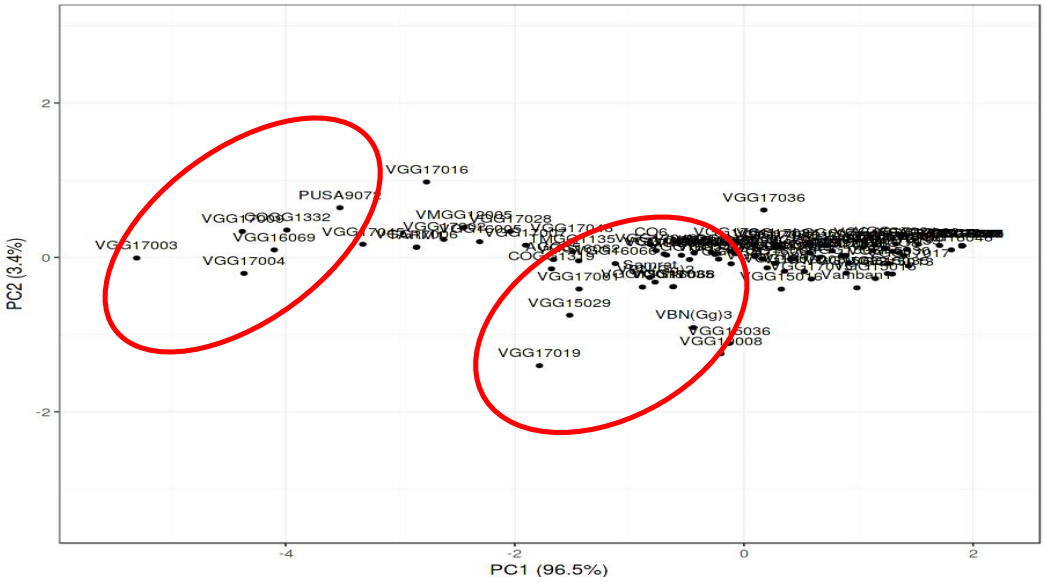


**Fig 1:** Principal Component Analysis of seedling growth characters [Germination percentage (%), Promptness index and Germination stress index (GSI)].

recorded higher germination percentage (mentioned in parenthesis along with the corresponding genotypes). At 0.5 MPa moisture stress no germination was observed in MGG387, NBL722, OBGG56, OBGG57, OBGG58, VGG 16003, VGG 16006, VGG 16027, VGG 16029, VGG 16035, VGG 16055, VGG 16058, VGG 17008, VGG 17021, VGG 17025, VGG 17032, VGG 17038, VGG 17049 and VGG 17050. The rate of germination was varying with the genotypes at -0.5 MPa. Decline in germination percentage due to lower water potential have been reported earlier in green gram (Dutta and Bera, 2008; Kaur *et al*., 2017). PI was higher in VGG 17003 (30.75), VGG 17009 (27.42), PUSA9072 (26.00), VGG 16069 (25.83), VGG 17004 (25.58), COGG1332 (25.17) at -0.5 MPa. Therefore, the lower water potential during germination inhibits the seed germination or suppress the growth and development of seedlings (Kaur *et al*., 2017).

The radicle length, plumule length and seed vigour in different genotypes were recorded in all the germinated seedlings of green gram genotypes. Maximum radicle length was observed in VGG 17014 (3.70cm) followed by VGG 17009 (3.33cm) and VGG 15030 (3.03cm) (Table 5). The mean radicle length of all genotypes measured 6.42 and 8.11cm in control and 1.23 and 0.00cm in -0.5 MPa respectively.

The seed vigour was significantly decreased in all the genotypes at -0.5 MPa as compared with the control. Among the genotypes TARM1 (240.79), VGG 17009 (200.72) showed higher seed vigour when compared with the other genotypes. At -0.5 MPa the plumule growth was completely retarded in all the green gram genotypes. The variation in germination and seedling growth characteristics was specific for genotypes under reduced water potential (Redona and Mackill, 1996). Similar results were also reported in green gram and black gram (De *et al*., 2005 ; Kaur *et al*., 2017).

The germination stress index and root length stress index was also calculated for different genotypes (Table 5). The GSI was higher in VGG 17003 (67.36), VGG 17009 (61.68), COGG1332 (59.48), VGG 17004 (58.32), VGG 16069 (56.72), PUSA9072 (52.56) genotypes which indicates higher level of tolerance to drought. The germination stress index is one of the indicative measurements for the speed of germination and development of seedlings at lower water potential. The genotypes has recorded high GSI has faster development. Many of the studies reported that the GSI can be used as a screening criterion for drought tolerance in pulses (Ahmad *et al*., 2009; Dhopte and Livera, 1989). The root length stress index was higher in TARM1 (75.46) and VGG 16061 (67.63).

### Principal component analysis (PCA)

Principal component analysis (PCA; Fig 1) of various traits such as germination percentage, promptness index and GSI was compared in all the green gram genotypes. In this study PC1 (germination percentage) showed wide variance than the other component. PC1 describes 96.5% of the variance; PC2 describes 3.4% of the variance. Among 108 genotypes VGG17009, PUSA 9072, COGG1332, VGG 17003, VGG 17004, VGG 16069, VGG 10008,VGG 15029, VGG 17001 and VGG 17019 these genotypes were split and spread widely into different groupings which showed higher germination percentage, promptness index and germination stress tolerance index.

## CONCLUSION

The green gram genotypes were screened for their responses to drought on the basis of germination percentage, germination stress index and seed vigour. The

green gram genotypes COGG1332, VGG 16069, VGG 17003, VGG 17004, VGG 17009, VGG 17019, VGG 17045 were showed better tolerance (>50% germination percentage) to drought stress during germination stage. The selected genotypes have been observed to possess tolerance traits to withstand under drought stress and can be used for further investigations.

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### Conflict of interest

The authors declare that they have no conflict of interest.

## REFERENCES

Agrawal, R.L. (1980). Seed technology. Seed Technology. Seed Industry and Trade. Oxford and IBH Publications.pp 685

Ahmad, S., Ahmad, R., Ashraf, M.Y., Ashraf, M., and Waraich, E.A. (2009). Sunflower (*Helianthus anus* L.) response to drought stress at germination and seedling growth stages. Pakistan Journal of Botany. 41(2): 647-654.

Cutforth, H.W., McGinn, S.M., McPhee, K.E. and Miller, P.R. (2007). Adaptation of pulse crops to the changing climate of the Northern Great Plains. Agronomy Journal. 99(6): 1684-1699.

De, R., Sinhababu, A., Banerjee, A. and Kar, R.K. (2005). Effect of water stress on seed germination and seedling growth in mungbean and blackgram. Crop Research. 29(1): 148-155.

Dhopte, A.M. and Livera, M. (1989). Few tests for various stresses in crop plants: seed germination test for drought tolerance. In: Useful Techniques for Plant Scientists.[(EdS.). AM Dhopte and M. Livera]. Forum for Plant Physiologists, Akola, India. 95: 96.

Dutta, P. and Bera, A.K. (2008). Screening of mungbean genotypes for drought tolerance. Legume Research. 31(2): 145-148.

Eck, H.V. (1986). Effects of water deficits on yield, yield components and water use efficiency of irrigated corn. Agronomy Journal. 78(6): 1035-1040.

Feller, U. (2006). Stomatal opening at elevated temperature: An underestimated regulatory mechanism. General and Applied Plant Physiology. 32: 19-31.

George, D.W. (1967). High temperature seed dormancy in wheat (*Triticum aestivum* L.). Crop Science. 7(3): 249-253.

Hardegree, S.P. and Emmerich, W.E. (1990). Effect of polyethylene glycol exclusion on the water potential of solution-saturated filter paper. Plant Physiology. 92(2): 462-466.

Hasanuzzaman, M. and Fujita, M. (2011). Selenium pretreatment upregulates the antioxidant defense and methylglyoxal detoxification system and confers enhanced tolerance to drought stress in rapeseed seedlings. Biological Trace Element Research. 143(3): 1758-1776.

Hsiao, T.C. (1973). Plant responses to water stress. Annual Review of Plant Physiology. 24(1): 519-570.

Ihsan, M.Z., Shahzad, N., Kanwal, S., Naeem, M., Khaliq, A., El-Nakhlawy, F.S. and Matloob, A. (2013). Potassium as foliar supplementation mitigates moisture induced stresses in mung bean (*Vigna radiata* L.) as revealed by growth, photosynthesis, gas exchange capacity and Zn analysis of shoot. International Journal of Agronomy and Plant Production. 4: 3828-3835.

Kaur, R., Kaur, J. and Bains, T.S. (2017). Screening of mungbean genotypes for drought tolerance using different water potential levels. Journal of Advanced Agricultural Technologies. 4(2).

Maiti, R.K., de la Rosa-Ibarra, M. and Sandoval, N.D. (1994). Genotypic variability in glossy sorghum lines for resistance to drought, salinity and temperature stress at the seedling stage. Journal of Plant Physiology. 143(2): 241-244.

Nair, R.M., Schafleitner, R., Kenyon, L., Srinivasan, R., Easdown, W., Ebert, A.W., and Hanson, P. (2012). Genetic improvement of mungbean. SABRAO Journal of Breeding and Genetics. 44(2): 177-190.

Redona, E.D. and Mackill, D.J. (1996). Genetic variation for seedling vigor traits in rice. Crop Science. 36(2): 285-290.

Sharma, K.K. and Lavanya, M. (2002). Recent developments in transgenics for abiotic stress in legumes of the semi-arid tropics. JIRCAS Working Report No.23. 23: 61-73.