Original Research Article

Evaluation of Soybean Germplasm Lines for Agro-Morphological Traits and Terminal Drought Tolerance

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A B S T R A C T

The occurrence of drought stress at seed filling stage is known to cause severe yield reduction in soybean especially where the crop is grown in rainfed conditions. Screening of large germplasm lines under natural drought conditions is extremely difficult to execute due to unusual rains. In the present study, about 328 germplasm lines are screened for terminal drought tolerance by spraying 0.2% of potassium iodide (KI) at R5 stage and the tolerant lines were again retested under similar conditions in the subsequent year. The lines were classified as tolerant, moderately tolerant and susceptible based on the relative reduction in seed yield and 100-seed weight of treated over control conditions. The Shannon diversity index (SDI) indicated that genotypes were highly diverse for seed color (H= 1.20) and hilum colour (H= 0.93). The PCA biplot analysis revealed that lines were more compactly and closely placed under controlled conditions as against treated. Four genotypes (TGX1835-3E, VSL-69, EC-105780 and PK-1243) were identified as relatively drought tolerant lines as they showed less reduction for number of pods per plant, seed yield and hundred seed weight under KI induced drought conditions. These lines were again validated next year and were found to be potential source for the development of drought tolerant varieties for the sustainable soybean production.

Keywords
Terminal, Germplasm accessions, Potassium Iodide (KI), Soybean, drought tolerance

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Introduction

Soybean (Glycine max L. (Merrill) is one of the leading oilseed crops grown for its edible oil and protein in India as well as world over. Soybean seed contains over 40% protein and 20% oil and 35% carbohydrate (Liu et al., 1997) and its milk is considered as important source of food to infants in china. Recent studies have indicated that consumption of soybean reduces cancer, blood serum cholesterol, osteoporosis and heart disease.
It is also a good source of minerals, vitamins, folic acid and iso-flavones which are credited with slow development of these diseases (Wilson et al., 2004). In India more than 90% of soybean area is under rainfed conditions and the frequency of droughts is common phenomenon. Drought is one of the single most factors responsible for more than 50% reduction in soybean yields (Boyer et al., 1982; Bray et al., 2000). Soybean cultivation in India is overly dependent on seasonal monsoon rains which are erratic and uneven, causing termination of growth from germination to seed filling (Joshi and Bhatia, 2003). Drought is known to affect soybean yield by affecting all stages of plant growth and development; from germination to flowering, and seed filling to development as well as seed quality (Siddique et al., 2001; Manavalan et al., 2009). Occurrence of drought stress during vegetative stage can be compensated with rains during later part of crop growth, however drought at terminal growth stage especially during seed filling to seed maturity stage would cause severe yield loss which could not be recovered by any means (Sionit and Kramer, 1977; Hirasawa et al., 1994; Saitoh et al., 1999). Terminal drought stress in soybean causes gradual reduction in photosynthetic rate, followed by senescence of leaves and reduced seed size that finally results in reduced grain yields (Brevedan and Egli, 2003; Manavalan et al., 2009). Reduced photosynthetic rate affects the synthesis and transportation of photosynthates from leaf to the seed causing reduction in seed size. However photosynthates stored in stem acts as reserves plays a pivotal role in substituting factor for seed filling and seed development in soybean (Constable and Hearn, 1978). From stem reserves (Constable and Hearn, 1978).

One of the most sustainable ways to overcome the recurring and perennial problem of drought and to make soybean production more stable and sustainable is to develop climate resilient soybean genotypes with relatively drought tolerant to tide over short periods of drought stress at seed filling stage. Yield losses could be greatly reduced by identifying and adopting drought tolerant genotypes. However, no systematic breeding efforts for developing drought tolerant soybean genotypes are limiting due to the lack of proper and reliable field screening techniques. Field screening of large germplasm lines by withholding irrigation facility at particular stage is rather more cumbersome and time consuming as well as difficult execute due to monsoon rains. Few techniques were developed and standardized to stimulate drought like conditions under field conditions with the application of chemicals. Various indices/parameters have been adopted to quantify drought tolerance in soybean genotypes and other crops (Ku et al., 2013). Potassium Iodide (KI) is known to mimic drought stress under natural conditions, it acts as desiccant on plants by reducing photosynthetic rate, chlorophyll content and senescence with increased content of sucrose and proline content (Sawhney and Singh, 2002) and the effect of drought stress on seed weight reduction could be compared with that of natural drought stress conditions. A single spray of KI at reproductive stage especially during seed filing stage (Blum et al., 1983a; Bouslama et al., 1984; Regan et al., 1993) helps in differentiating genotypes based on their ability to form viable seeds and this method of screening is used to evaluate large number of germplasm lines for terminal drought tolerance traits in many crops (Nicolas and Turner, 1993; Royo and Blanco, 1998, Ashraf et al., 2003; Singh et al., 2012).
The present study was carried out to identify soybean lines tolerance to terminal drought tolerance.

Lack of progress in the development of drought tolerant varieties in soybean is mainly attributed to non-availability of proper screening facilities, poor understanding of physiological and biochemical responses of soybean varieties to drought (Bhatia et al., 2014). Keeping these potential research gaps in view, the present investigation was formulated to evaluate the soybean germplasm for agro-morphological traits and terminal drought tolerance induced by KI under the field conditions. The main objectives of this study were (i) Evaluation of soybean germplasm lines for agro-morphological traits (ii) screening for terminal drought tolerance using KI (Potassium Iodide) and (iii) Identifying the soybean genotypes for drought tolerance.

Materials and Methods

Experimental site and weather conditions

The experiment was laid out at India Council of Agricultural Research-Indian Agricultural Research Institute (ICAR-IARI), New Delhi, India. The experimental farm has sandy loam to loamy soil with pH of 7.5 having semi-arid subtropical climate with an average temperature ranging from 19 to 32°C (July to November).

Experimental material and field evaluation

The experimental material consists of a 328 soybean germplasm lines (Table 1) selected randomly from Germplasm Management Unit at Division of Genetics, ICAR-IARI, Pusa Campus, New Delhi. Each accession was planted in two rows of three meter length, sown during 1st week of July 2014 in an augmented block design (Federer 1956) along with five checks varieties viz., Pusa 9712, SL 688, PS 1347 Ps 1092 and Bragg. The checks were replicated once after every 10 germplasm lines. The recommended row-to-row and plant-to-plant spacing of 45 and 5cm respectively was followed and all the agronomic practices were carried out timely to raise a healthy crop. The crop was raised by providing regular irrigation facilities without any biotic or abiotic stress symptoms until the seed filling stage (R5). At R5 stage the plants of one replication was sprayed/drenched completely with 0.2% of Potassium Iodide (KI) to mimic terminal drought stress (Bhatia et al., 2014). Severity of terminal drought on germplasm lines was measured based on percent reduction of seed yield and 100-seed weight in treated as against normal was calculated and genotypes were grouped in to three different classes viz., Tolerant (0 – 20%), Moderately susceptible (20.1 – 45%), susceptible (45.1 – 70%) as described by Bhatia et al., (2014). The following traits were recorded from five randomly selected plants from each genotype of both control and treated plots and mean values were computed for analysis purposes. The quantitative traits were Days to 50 per cent flowering (DFF), Days to full maturity (DFM), Plant height (PH), Number of seeds per pod (NSP), Number of pods per plant (NPP), Hundred seed yield (HSW), Single plant yield (SPY) and Row yield (RY). Ten qualitative traits were recorded at flowering stage was growth habit, leaf shape, flower color, pod color, pod pubescence, pubescence color, seed shape, seed color, seed luster and hilum color. During second season (2015), 40 genotypes were chosen based on first year (2014) field screening results in such a way that equal number of lines from tolerant, moderately susceptible and susceptible lines for terminal drought tolerance trait and five check varieties were planted in a randomized block design consisting of two replications (Table 1b). One replication was imposed
terminal drought stress at R₅ stage by drenching KI at 0.2% and the lines were screened for drought tolerance by recording seed yield and its contributing traits. Diversity parameters were calculated for qualitative traits by taking account of allelic richness (calculated from descriptor states) and allelic evenness through Shannon Diversity Index (SDI) (Shannon and Weaver, 1949) as follows:

\[
SDI_i = \sum_{j=1}^{d_i} P_{ij} \cdot \log P_{ij}
\]

Where SDIᵢ = SDI for iᵗʰ descriptor, di = descriptor state for iᵗʰ descriptor, pij = the proportion of accessions for jᵗʰ descriptor states of iᵗʰ descriptor. Analysis of variances (ANOVA) was carried out using SAS 9.3 software (SAS Institute Inc., Cary, NC, USA). Estimate of co-efficient of variation (CV) was calculated as per the standard formulae (Burton 1952) and expressed in percent.

Principal Components Analysis (PCA) was done using XL stat.

**Results and Discussion**

**Diversity analysis**

The Shannon diversity index (SDI) for 10 qualitative traits of the 328 germplasms lines were presented in Table 4. The highest SDI observed for seed colour (1.20) and lowest for pod pubescence (0.13) and with a mean of 0.57. This indicates that germplasms are highly diverse for seed colour (H' = 1.20) and hilum colour (H' = 0.93), whereas it is lowest for pod pubescence (H' = 0.13), pod colour (H' = 0.21) and leaf shape (H' = 0.25). Gangopadhyay et al., (2016) reported high species diversity for intensity of stem colour, leaf shape, epicalyx shape, 13 quantitative characters and 3 biotic stress parameters between wild and cultivated species of Okra using SDI. In another study, Upadhya et al., (2001) reported that SDI was used to classify chickpea core collection accessions into desi, intermediate and kabuli types based on 7 morphological descriptors and 15 agronomic characters.

**Evaluation accessions for agromorphological characters**

Descriptive statistics for 328 genotypes under control and treated conditions were presented in Table 2c. The analysis of variance for control and treatment plots during 2014 season has revealed significant differences (p<0.05) for all morphological traits except for 100-seed weight (HSW) under control conditions and number of seeds per pod (NSPP) as well as single plant yield (SPY) under control and treated conditions (Table 2a&b). This indicates that there is sufficient quantity of variability present in the germplasm lines included in the present study for quantitative traits. The coefficient of variation ranged from 2.43% (days to 50% flowering) to 18.76% (row yield) under normal conditions where as under KI treated conditions it varied from 2.61% (days to 50% flowering) to 25.58% (single plant yield). Whereas during second season (2015) all the traits number of seeds per pod (NSPP) under control conditions, exhibited significant differences (p<0.05) for all quantitative traits. The random sample selected based on the first season results do possess much variability for all the characters. Coefficient of variation varied from 1.33 (Days to full maturity) to 47.62 (number of seeds per pod) under controlled conditions, whereas it was 5.31 (Plant height) to 24.55 (number of pods per plant) under KI treated conditions (Table 3a&b).

**Principle component analysis**

Terminal drought occurs when plants are exposed to water deficit during later stages of crop growth especially seed filling and seed
development. The greatest loss occurs when the drought occurs during flowering stage (Frahm et al., 2004). The effect of drought on the plant and its reactions depend also on duration and intensity of stress (Brar et al., 1990). Principal components (PCs) and Eigen values of quantitative traits were analyzed to determine percent contribution of individual trait to the diversity under both the conditions is presented in Table 4a and b. Based on Eigen value of more than 1, PC1 and PC2 together explained 64.80% variation and 61.71% variation under controlled and treated conditions respectively. To be specific PC1 alone accounted 51.23% and 46.77% of variance under normal and treated conditions respectively. Remaining components contributed 35.20% under control and 38.23% under treated conditions to total diversity. The traits 100-seed weight, number of pods/plant, no of seeds/pod, row yield and single plant yield had major contributions towards PC1 and for PC2 the maximum variation contributed by plant height, number of seeds per plant, Days to 50% flowering, Days to full maturity, hundred seed weight and single plant yield under control conditions (Table 5c). Under KI treated conditions highest variation in PC1 was contributed by hundred seed weight, number of pods per plant, number of seeds per plant, row yield and single plant yield and in case of PC2, the main traits which contributed to maximum variation was days to 50% flowering, days to full maturity, plant height, single plant yield, number of seeds per pod and hundred seed weight. Thus under both conditions PC1 is mainly related to economic yield traits, whereas PC2 for other vegetative traits. Similar results were found by Deepika et al., (2017) and Iqbal et al., (2008) in Soybean and Gangopadhyay et al., (2016) in okra. The PCA Biplot analysis indicated that genotypes were highly clustered and closely placed under control condition as compared with the treated conditions, they were loosely arranged due to the differential response of genotypes towards KI induced terminal drought stress (Fig. 1a & b). PC1 and PC2 having Eigen values higher than unity explained 82.55% of total variability among soybean genotypes attributed to seed yield (El-Hashash et al., 2016). In another study, Kargar et al., (2015) stated that, PC1, PC2 and PC3 contributed 32.57%, 27.20% and 15.02% to total variability and also explained 74.79% of traits variation with varimax rotation method under stress condition. Mahbub et al., (2016) has indicated that, the PCA yield four of the Eigen values above unity accounted for 91.55% of the total variation. The first three principles accounted for 83.23% of the total variation. In the table 5a, PC1 has highest positive load from single plant yield (17.22), row yield (15.93), number of pods per plant (15.58), days to full maturity (15.39) and days to 50% flowering (14.06) under normal conditions, but under KI treated conditions (Table 5b) single plant yield (18.75), number of pods per plant (18.29), days to full maturity (17.17) and row yield (16.30) has highest contribution to the total diversity. Quantitative traits contributed positively to first three principal components and hence these could be given considerable importance for the genetic material under investigation by Iqbal et al., (2008).

Screening of germplasm lines for terminal drought tolerance using KI

Presence of genetic variation for physiological traits is of the pivotal importance for the development of varieties for drought tolerance. Differential response of genotypes towards abiotic factors makes screening easy and effective in identification of drought tolerance genotypes. Lines expressing higher degree of tolerance towards terminal drought is characterized by their capacity in partition of photosynthates to the developing seeds after stress was imposed
(Nicolas and Turner, 1993; Ashraf et al., 2003; Singh et al., 2012). The faster rate of seed filling in few lines under KI treated conditions might have played a role in their ability to produce bigger seeds and higher seed yields that intern resulted in relative tolerance to terminal drought. In the present study, 328 germplasm lines were evaluated to identify terminal drought tolerant lines by the application of KI spray at R5 stage to create drought like situation. The mean seed yield per row under control conditions was 175.57 g with a range of 6 to 634.0 g, whereas under KI treated conditions the mean yield was 67.88 g with the range of 2.0 to 308.0 g (Table 6). The mean seed yield reduction is 61.50% under KI treated drought conditions as compared to control. The seed yield reduction among the entries varies from 1.94% to a as high as 97.44%. For seed yield per plant, the average under control is 8.86 g, whereas under treated conditions it is 4.26 g, the reduction under treated conditions varies from 0.54% to the highest of 95.01%. The mean hundred seed weight is 8.86 g and 4.26 g under control and treated conditions respectively. The average reduction for hundred seed weight is 33.41% under treated as compared with control conditions and the range of reduction varies from 0.62% to 96.67%. For pods per plant, the mean is 62.10% under control conditions, whereas it is 40.54% treated conditions. The average reduction for number of pods is 0.78% to 87.34%. The results have clearly indicated that there are large genotypic variations in response to KI spray induced drought stress in soybean germplasm lines. The lines were grouped into three different classes based on the percent reduction in seed yield and hundred seed weight of treated plots over control (Table 7). The genotypes, TGX1835-3E, VSL-69 and PK-1243 and EC-105790 has lowest (< 16.59%) reduction for seed yield and hundred seed weight under treated conditions and are considered as relatively tolerant to KI induced terminal drought stress, another group of lines consisting of G-2130, DS-9802, SL-633 and PKS-25 has a recorded 20.1 to 45% reduction for seed yield and hundred seed weight, whereas PK-1024, PK-1240, DS-2309 and UPSL-291 recorded the highest reduction (>50%) for seed yield and hundred seed weight under KI induced drought conditions.

**Validation of identified drought tolerant lines for yield traits under field conditions**

Performance of genotypes under KI induced terminal drought tolerance is verified further during next season (2015) by evaluating 40 genotypes based on first year results. Most genotypes showed consistent and similar responses like first year for all quantitative traits under KI induced terminal drought tolerance. Four terminal drought tolerant lines were identified during first year viz., TGX1835-3E, VSL-69, EC-105890 and PK-1243 were evaluated in second year for seed yield contributing traits under KI induced drought tolerance is discussed (Table 8). The average seed yield reduction ranged from 8.57% (EC-1055780) to 16.19% (PK-1243) under KI treated as compared to control. Seed yield per plant recorded 15.79% in EC-105780 to 19.59% in TRX1835-3E under treated over control. For hundred seed weight, the reduction is less than 10% across the four lines. From the above analysis, the lines (TGX1835-3E, VSL-69, EC-105780 and PK-1243) were identified as relatively drought tolerant in Kharif-2014 based on seed yield and hundred seed weight and had shown less than 20% reduction under treated conditions in the next season. The tolerant genotypes exhibited the capacity to produce healthy and normal seeds due to their ability to store the photosynthates in stem and translocate them to the developing seeds during drought like condition made them produce relatively good yields.
Table 1: List of soybean genotypes and their origin used for screening against terminal drought using KI during Kharif-2014

| S. No | Genotype  | Origin          | S. No | Genotype  | Origin          |
|-------|-----------|-----------------|-------|-----------|-----------------|
| 1     | BS-1      | BIRSA, Ranchi   | 44    | G-2132    | AVRDC           |
| 2     | BJJF-8    | Unknown         | 45    | IC-101449 | Indigenous collection |
| 3     | DS 74     | DS-Delhi        | 46    | IC-141446 | Indigenous collection |
| 4     | DS-76-1-3 | DS-Delhi        | 47    | JS-91-4  | Jabalpur        |
| 5     | DS-76-1-2-2 | DS-Delhi     | 48    | JS(SH)91-16 | sehore,MP |
| 6     | DS-76-1-2-3 | DS-Delhi     | 49    | KALITUR  | Indigenous collection |
| 7     | DS-MM-64  | DS-Delhi        | 50    | KG-83-1A | Kasbe-Digraj    |
| 8     | DS-93-108A| DS-Delhi        | 51    | KB-17     | Kasbe-Digraj    |
| 9     | DS-9703   | DS-Delhi        | 52    | L-377     | AVRDC           |
| 10    | DS-9802   | DS-Delhi        | 53    | L-416     | AVRDC           |
| 11    | EC-109514 | EC-exotic       | 54    | L-440     | AVRDC           |
| 12    | EC-109565 | EC-exotic       | 55    | L-587     | AVRDC           |
| 13    | EC-113396 | EC-exotic       | 56    | L-652     | AVRDC           |
| 14    | EC-114526 | EC-exotic       | 57    | L-680     | AVRDC           |
| 15    | EC-25720  | EC-exotic       | 58    | M-135     | AVRDC           |
| 16    | EC-76758  | EC-exotic       | 59    | M-53      | AVRDC           |
| 17    | EC-389148 | EC-exotic       | 60    | M-11913   | AVRDC           |
| 18    | EC-389179 | EC-exotic       | 61    | M-693     | AVRDC           |
| 19    | EC-389392 | EC-exotic       | 62    | MACS-57   | Pune            |
| 20    | EC-439618 | EC-exotic       | 63    | MAUS-71   | Parbhani        |
| 21    | EC-439619 | EC-exotic       | 64    | MAUS-311 | Parbhani        |
| 22    | EC-14436  | EC-exotic       | 65    | NRC 37    | Indore          |
| 23    | EC-39779  | EC-exotic       | 66    | PK-1162   | Pantnagar       |
| 24    | EC-39873  | EC-exotic       | 67    | PK-564    | Pantnagar       |
| 25    | EC-97351  | EC-exotic       | 68    | PK-1023   | Pantnagar       |
| 26    | EC-105790 | EC-exotic       | 69    | PK-1169   | Pantnagar       |
| 27    | EC-95299  | EC-exotic       | 70    | PK-1180   | Pantnagar       |
| 28    | G-395     | AVRDC           | 71    | PK-1223   | Pantnagar       |
| 29    | DS-12-13  | DS-Delhi        | 72    | PK-1240   | Pantnagar       |
| 30    | G-2253    | AVRDC           | 73    | PK-1243   | Pantnagar       |
| 31    | G-2265    | AVRDC           | 74    | PK-1250   | Pantnagar       |
| 32    | G-2344    | AVRDC           | 75    | PK-295    | Pantnagar       |
| 33    | G-2601    | AVRDC           | 76    | PLSO-6A   | Pantnagar       |
| 34    | G-2602    | AVRDC           | 77    | PLOS-91   | Pantnagar       |
| 35    | G-2603    | AVRDC           | 78    | SL-46     | PAU, Ludhiana   |
| 36    | G-2608    | AVRDC           | 79    | SL-432    | PAU, Ludhiana   |
| 37    | DS 2614   | DS-Delhi        | 80    | SL-443    | PAU, Ludhiana   |
| 38    | G-2631    | AVRDC           | 81    | SL-459    | PAU, Ludhiana   |
| 39    | G-2650    | AVRDC           | 82    | SL-284    | PAU, Ludhiana   |
| 40    | G-2651    | AVRDC           | 83    | TGX1828-4E | IITA, Nigeria  |
| 41    | G-2656    | AVRDC           | 84    | TGX1831-32E | IITA, Nigeria |
| 42    | G-2670    | AVRDC           | 85    | TGX1864-25F | IITA, Nigeria  |
| 43    | G-2130    | AVRDC           | 86    | TGX1835-3E | IITA, Nigeria   |
### Table 1 List of soybean genotypes and their origin used for screening against terminal drought using KI during Kharif-2014

| S. No | Genotype    | origin          | S. No | Genotype    | origin          |
|-------|-------------|-----------------|-------|-------------|-----------------|
| 87    | TGX1973-14 | IITA, Nigeria   | 130   | UPSV-22     | Pantnagar       |
| 88    | TGX1019-2FB| IITA, Nigeria   | 131   | UPSV-24     | Pantnagar       |
| 89    | TAMS-38     | BARC-amravati   | 132   | UPSV-65A    | Pantnagar       |
| 90    | UGM-47      | AVRDC           | 133   | UPSV-72     | Pantnagar       |
| 91    | UGM-77      | AVRDC           | 134   | UPSV-19     | Pantnagar       |
| 92    | UPSL-19     | Pantnagar       | 135   | UPSV-31     | Pantnagar       |
| 93    | UPSL-34     | Pantnagar       | 136   | VLS-17      | VPKS, Almora    |
| 94    | UPSL-54     | Pantnagar       | 137   | EC-439597   | EC-exotic      |
| 95    | UPSL-62     | Pantnagar       | 138   | EC-439606   | EC-exotic      |
| 96    | UPSL-64     | Pantnagar       | 139   | EC-389170   | EC-exotic      |
| 97    | UPSL-92     | Pantnagar       | 140   | EC389116    | EC-exotic      |
| 98    | UPSL-152    | Pantnagar       | 141   | EC458355    | EC-exotic      |
| 99    | UPSL-156-B  | Pantnagar       | 142   | EC-458383   | EC-exotic      |
| 100   | UPSL-162    | Pantnagar       | 143   | EC-456525   | EC-exotic      |
| 101   | UPSL-163    | Pantnagar       | 144   | SL 525      | PAU, Ludhiana  |
| 102   | UPSL-180    | Pantnagar       | 145   | EC-456616   | EC-exotic      |
| 103   | UPSL-181    | Pantnagar       | 146   | EC-456639   | EC-exotic      |
| 104   | UPSL-211    | Pantnagar       | 147   | EC-457772   | EC-exotic      |
| 105   | SL-525      | PAU, Ludhiana   | 148   | EC-471315   | EC-exotic      |
| 106   | UPSL-291    | Pantnagar       | 149   | EC-471319   | EC-exotic      |
| 107   | UPSL-298    | Pantnagar       | 150   | EC-471851   | EC-exotic      |
| 108   | UPSL-309    | Pantnagar       | 151   | EC-471853   | EC-exotic      |
| 109   | UPSL-326    | Pantnagar       | 152   | EC-471870   | EC-exotic      |
| 110   | UPSL-332-B  | Pantnagar       | 153   | EC-471881   | EC-exotic      |
| 111   | UPSL-340-B  | Pantnagar       | 154   | EC-471882   | EC-exotic      |
| 112   | UPSL-343    | Pantnagar       | 155   | EC-471909   | EC-exotic      |
| 113   | UPSL-505    | Pantnagar       | 156   | EC-471910   | EC-exotic      |
| 114   | UPSL-652    | Pantnagar       | 157   | EC-471920   | EC-exotic      |
| 115   | UPSL-656    | Pantnagar       | 158   | EC-471921   | EC-exotic      |
| 116   | UPSL-706    | Pantnagar       | 159   | EC-471936   | EC-exotic      |
| 117   | UPSL-736    | Pantnagar       | 160   | EC-471937   | EC-exotic      |
| 118   | UPSL-558    | Pantnagar       | 161   | EC-471956   | EC-exotic      |
| 119   | UPSL-769    | Pantnagar       | 162   | EC-471967   | EC-exotic      |
| 120   | UPSL-782    | Pantnagar       | 163   | EC-471969   | EC-exotic      |
| 121   | UPSL-784    | Pantnagar       | 164   | EC-471972   | EC-exotic      |
| 122   | UPSL-785    | Pantnagar       | 165   | EC-471979   | EC-exotic      |
| 123   | UPSL-786    | Pantnagar       | 166   | EC-471981   | EC-exotic      |
| 124   | UPSL-787    | Pantnagar       | 167   | EC-472119   | EC-exotic      |
| 125   | UPSL-57     | Pantnagar       | 168   | EC-472120   | EC-exotic      |
| 126   | UPSM-595    | Pantnagar       | 169   | EC-472162   | EC-exotic      |
| 127   | UPSV-2      | Pantnagar       | 170   | EC-472173   | EC-exotic      |
| 128   | UPSV-19     | Pantnagar       | 171   | EC-475184   | EC-exotic      |
| 129   | SL 525      | PAU, Ludhiana   | 172   | EC-472197   | EC-exotic      |
**Table 1** List of soybean genotypes and their origin used for screening against terminal drought using KI during Kharif-2014

| S. No | Genotype | origin  | S. No | Genotype | origin |
|-------|----------|---------|-------|----------|--------|
| 173   | EC-472199 | EC-exotic | 216   | PK-1251  | Pantnagar |
| 174   | EC-472202 | EC-exotic | 217   | PK-1259  | Pantnagar |
| 175   | EC-472203 | EC-exotic | 218   | PK-1274  | Pantnagar |
| 176   | EC-471720 | EC-exotic | 219   | PK-1283  | Pantnagar |
| 177   | EC-457191 | EC-exotic | 220   | 19-P3    | Indore |
| 178   | RKS      | Kota, Rajasthan | 221 | 19-P3    | Indore |
| 179   | SL-637   | PAU, Ludhiana | 222 | JS-2000-20 | Jabalpur |
| 180   | UGM-20075 | Pantnagar | 223   | MRSB-352 | Unknown |
| 181   | PK-1387  | Pantnagar | 224   | NRC 65   | Indore |
| 182   | HiMSO-1598 | Palampur | 225   | PS-1370  | Pantnagar |
| 183   | PK-1347  | Pantnagar | 226   | RKS-15   | Kota, Rajasthan |
| 184   | TS-148-22 | BARC | 227   | TS-39    | BARC |
| 185   | MACS-757 | Pune | 228   | SL-518   | PAU, Ludhiana |
| 186   | MACS-869 | Pune | 229   | HiMSO-1602 | Palampur |
| 187   | TS-3     | BARC | 230   | HiMSO-24 | Palampur |
| 188   | SL-633   | PAU, Ludhiana | 231 | PS-1374  | Pantnagar |
| 189   | DS-200   | DS-Delhi | 232   | PS-1394  | Pantnagar |
| 190   | DS-960   | DS-Delhi | 233   | JS (SH)-40 | Sehore, MP |
| 191   | PS-9813  | Pantnagar | 234   | JS(SH)-40 | Sehore, MP |
| 192   | PS-9816  | Pantnagar | 235   | MRSB-345 | Unknown |
| 193   | PS-9817  | Pantnagar | 236   | VSL 61   | PAU, Ludhiana |
| 194   | PS-9819  | Pantnagar | 237   | SL 679   | PAU, Ludhiana |
| 195   | PS-9820  | Pantnagar | 238   | SL-710   | PAU, Ludhiana |
| 196   | PS-9822  | Pantnagar | 239   | PK-1347  | Pantnagar |
| 197   | DS-9814  | DS-Delhi | 240   | SL 637   | PAU, Ludhiana |
| 198   | DS-9721  | DS-Delhi | 241   | PS-633   | Pantnagar |
| 199   | HiMSO-1563 | Palampur | 242   | PS-1368  | Pantnagar |
| 200   | HiMSO-1587 | Palampur | 243   | SL-638   | PAU, Ludhiana |
| 201   | JS-94-67 | Jabalpur | 244   | AMS-99-22 | Amravati |
| 202   | JS-(SH)-95-26 | Sehore | 245   | SL-751   | PAU, Ludhiana |
| 203   | KB-222   | Kasbe-Digraj | 246   | PKS-25   | Pantnagar |
| 204   | Lee      | USA | 247   | AMS-353  | Amravati |
| 205   | MAUS-62-2 | Parbhani | 248   | SL-717   | PAU, Ludhiana |
| 206   | MAUS-64-1 | Parbhani | 249   | PKS-34   | Pantnagar |
| 207   | MAUS-31  | Parbhani | 250   | AMS-47   | Amravati |
| 208   | NRC 45   | Indore | 251   | PS-1403  | Pantnagar |
| 209   | NRC 47   | Indore | 252   | MAUS-231 | Parbhani |
| 210   | NRC 51   | Indore | 253   | NRC-72   | Indore |
| 211   | NRC 53   | Indore | 254   | MAUS-49-1-2 | Parbhani |
| 212   | PK-1024  | Pantnagar | 255   | PS-1410  | Pantnagar |
| 213   | PK-1041  | Pantnagar | 256   | TANUS-55 | TNAU |
| 214   | PK-1060  | Pantnagar | 257   | VLS-65   | VPKS, Almora |
| 215   | PK-1081  | Pantnagar | 258   | KDS-256  | Kasbe-Digraj |
Table 1 List of soybean genotypes and their origin used for screening against terminal drought using KI during Kharif-2014

| S. No | Genotype | origin       | S. No | Genotype | origin       |
|-------|----------|--------------|-------|----------|--------------|
| 259   | PS-1420  | Pantnagar    | 302   | NRC-89   | Indore       |
| 260   | PS-1415  | Pantnagar    | 303   | DSb-19   | Dharwad      |
| 261   | PKS-36   | Pantnagar    | 304   | JS-20-38 | Jabalpur     |
| 262   | SL-738   | PAU, Ludhiana| 305   | KBS-2011 | Kasbe-Digraj |
| 263   | MACS-1037| Pune         | 306   | VLS-201  | VPKS, Almora |
| 264   | NRC-24   | Indore       | 307   | KBS-2010 | Kasbe-Digraj |
| 265   | DS-2309  | DS-Delhi     | 308   | DS-2706  | DS-Delhi     |
| 266   | SL-747   | PAU, Ludhiana| 309   | PS-1499  | Pantnagar    |
| 267   | VLS-66   | VPKS, Almora | 310   | RKS-66   | Kota, Rajasthan |
| 268   | Dsb-9    | Dharwad      | 311   | NRC-89   | Indore       |
| 269   | AMS-99-33| Amravati     | 312   | VLS 81   | Almora       |
| 270   | Dsb-10   | Dharwad      | 313   | AMS-56   | Amravati     |
| 271   | PS-1437  | Pantnagar    | 314   | JS 2038  | Jabalpur     |
| 272   | NSO-111  | MAHYCO       | 315   | PS 1503  | Pantnagar    |
| 273   | SL-452   | PAU, Ludhiana| 316   | HiMSO 1681 | Palampur |
| 274   | MACS-1126| Pune         | 317   | MACS 1364| Pune         |
| 275   | NSO-78   | MAHYCO       | 318   | KDS 701  | Kasbe-Digraj |
| 276   | NRC-78   | Indore       | 319   | MAUS 608 | Parbhani     |
| 277   | MAUS-295 | Parbhani     | 320   | KBS 2011 | Kasbe-Digraj |
| 278   | SL-790   | PAU, Ludhiana| 321   | NRC-94   | Indore       |
| 279   | AMS-4-63 | Amravati     | 322   | RKS-115  | Kota, Rajasthan |
| 280   | NRC-76   | Indore       | 323   | VLS-84   | Almora       |
| 281   | PS-1454  | Pantnagar    | 324   | NRC-93   | Indore       |
| 282   | MACS-1184| Pune         | 325   | MACS-1416| Pune         |
| 283   | PS-1450  | Pantnagar    | 326   | PS-1521  | Pantnagar    |
| 284   | DS-2614  | IARI, Delhi  | 327   | NRC-91   | Indore       |
| 285   | JS-20-05 | Jabalpur     | 328   | MACS-1394| Pune         |
| 286   | JS-20-19 | Jabalpur     |       | Checks    |              |
| 287   | JS(SH)-2 | Sehore       | 329   | Pusa 9712| IARI, Delhi  |
| 288   | Dsb-15   | Dharwad      | 330   | SL 688   | PAU, Ludhiana|
| 289   | PS-1466  | Pantnagar    | 331   | PS 1347  | Pantnagar    |
| 290   | MACS-1259| Pune         | 332   | PS 1092  | Pantnagar    |
| 291   | JS-20-21 | Jabalpur     | 333   | Bragg     | USA          |
| 292   | PS-1476  | Pantnagar    |       |          |              |
| 293   | DS-12-5  | DS-Delhi     |       |          |              |
| 294   | PS-1480  | Pantnagar    |       |          |              |
| 295   | SL-871   | PAU, Ludhiana|       |          |              |
| 296   | DS-27-11 | DS-Delhi     |       |          |              |
| 297   | MACS 1340| Pune         |       |          |              |
| 298   | JS 20-35 | Jabalpur     |       |          |              |
| 299   | JS(SH)-93-37| Sehore | |          |              |
| 300   | KBS-2010 | Kasbe-Digraj |       |          |              |
| 301   | SL-900   | PAU, Ludhiana|       |          |              |
**Table 1a** List of soybean genotypes used for screening against terminal drought using KI during Kharif-2015

| S. No | Genotype       | S. No | Genotype       |
|-------|----------------|-------|----------------|
| 1     | DS-9802        | 24    | VSL-61         |
| 2     | EC-97351       | 25    | SL-679         |
| 3     | EC-105790      | 26    | PK-1347        |
| 4     | G-2130         | 27    | PS-1368        |
| 5     | PK-1169        | 28    | SL-751         |
| 6     | PK-1180        | 29    | PKS-25         |
| 7     | PK-1240        | 30    | PKS-34         |
| 8     | PK-1243        | 31    | AMS-47         |
| 9     | SL-46          | 32    | KDS-256        |
| 10    | SL-432         | 33    | PS-1420        |
| 11    | TGX1828-4E     | 34    | PS-1415        |
| 12    | TGX1835-3E     | 35    | DS-2309        |
| 13    | UPSL-291       | 36    | MACS-1126      |
| 14    | UPSL-298       | 37    | NRC-78         |
| 15    | EC-471979      | 38    | KBS-2010       |
| 16    | SL-633         | 39    | AMS-56         |
| 17    | HiMSO-1563     | 40    | PS-9818        |
| 18    | HiMSO-1587     |       |                |
| 19    | KB-222         | 1     | Pusa-9712      |
| 20    | PK-1024        | 2     | SL-688         |
| 21    | JS-2000-20     | 3     | PS-1347        |
| 22    | RKS-15         | 4     | PS-1092        |
| 23    | TS-39          | 5     | Bragg          |
Table 2a Analysis of variance for growth and yield parameters of germplasm lines grown under control conditions Kharif-2014

| Source of variation     | df | Days to 50% flowering | Days to full maturity | 100-seed weight | No. of pods per plant | No. of seeds per pod | Plant height | Row yield | Single plant yield |
|-------------------------|----|------------------------|-----------------------|----------------|-----------------------|----------------------|--------------|-----------|-------------------|
|                         |    |                        |                       |                |                       |                      |              |           |                   |
| Block                   | 6  | 5.86 NS (0.6715)       | 18.86 NS (0.068)     | 1.05 NS (0.4536) | 77.18 NS (0.1635)    | 0.02 NS (0.4481)    | 57.90 NS (0.6581) | 4983.62 NS (0.0031) | 3.90 NS (0.1065) |
| Treatments              | 332| 61.14 ** (<.0001)     | 47.38 ** (<.0001)    | 7.00 ** (<.0001) | 807.63 ** (<.0001)   | 0.22 ** (<.0001)    | 173.38 (0.0175) | 20047.16 ** (<.0001) | 34.74 ** (<.0001) |
| Tests                   | 327| 52.54 ** (<.0001)     | 44.45 ** (<.0001)    | 6.59 ** (<.0001) | 773.05 ** (<.0001)   | 0.20 ** (<.0001)    | 159.36 (0.0303) | 12664.38 ** (<.0001) | 28.60 ** (<.0001) |
| Among Checks            | 4  | 641.1 ** (<.0001)     | 233.33 ** (<.0001)   | 4.76 (0.0075)   | 1341.23 ** (<.0001)  | 0.020 NS (0.4269)  | 1240.74 (0.0001) | 94343.21 ** (<.0001) | 3.84 NS (0.1325)  |
| Test V/s Checks         | 1  | 594.05 ** (<.0001)    | 271.78 ** (<.0001)   | 154.84 ** (<.0001) | 10975.14 ** (<.0001) | 5.70 ** (<.0001)    | 564.13 (0.0158) | 2198899.89 ** (<.0001) | 2363.53 ** (<.0001) |
| Error                   | 24 | 8.70                   | 8.21                 | 1.06           | 45.32                 | 0.02               | 83.66       | 1085.16   | 1.96              |
| CD at 5% Among Test     |    | 9.43                   | 9.16                 | 3.29           | 21.52                 | 0.54              | 29.24       | 105.32    | 4.47              |
| CD at 5% Test V/s checks|    | 6.97                   | 6.78                 | 2.43           | 15.92                 | 0.399             | 21.64       | 77.32     | 3.31              |
| CV (%)                  |    | 5.41                   | 2.43                 | 11.99          | 10.83                 | 6.54              | 12.63       | 18.76     | 15.77             |

NS: Non significant; ** highly significant; * significant; values in parenthesis indicate the Probability value (Pr>F).
### Table 2b:  Analysis of variance for growth and yield parameters of germplasm lines sprayed with Potassium Iodide (KI) Kharif-2014

| Source of variation       | df | Days to 50% flowering | Days to full maturity | 100-seed weight | No. of pods per plant | No. of seeds per pod | Plant height | Row yield | Single plant yield |
|---------------------------|----|-----------------------|-----------------------|-----------------|-----------------------|----------------------|--------------|-----------|-------------------|
| Block                     | 6  | 10.69<sup>NS</sup>   | 14.38<sup>NS</sup>   | 1.29<sup>NS</sup> | 11.66<sup>NS</sup>   | 0.26<sup>NS</sup>    | 108.15<sup>NS</sup> | 224.59<sup>NS</sup> | 0.86<sup>NS</sup> |
| Treatments                | 332| 63.49<sup)**</sup>   | 44.32<sup>**</sup>   | 5.09<sup>**</sup>  | 486.83<sup>**</sup> | 0.27*                 | 112.18<sup>*</sup> | 5489.24<sup>**</sup> | 11.17<sup>**</sup> |
| Tests                     | 327| 54.97<sup>**</sup>   | 42.05<sup>**</sup>   | 4.63<sup>**</sup>  | 409.94<sup>**</sup> | 0.26<sup>*</sup>     | 97.68<sup>*</sup>  | 3668.83<sup>**</sup> | 8.79<sup>**</sup> |
| Among Checks              | 4  | 626.54<sup>**</sup> | 200.1<sup>**</sup>  | 4.53<sup>*</sup>  | 646.06<sup>**</sup> | 0.08<sup>NS</sup>   | 1313.51<sup>**</sup> | 50311.19<sup>**</sup> | 1.65<sup>NS</sup> |
| Test V/s Checks           | 1  | 615.20<sup>**</sup> | 175.03**            | 159.67**        | 25616.84<sup>**</sup> | 5.38**               | 49.43<sup>NS</sup>   | 411856.43<sup>**</sup> | 809.06<sup>**</sup> |
| Error                     | 24 | 11.99                 | 8.41                 | 1.01            | 41.28                 | 0.07                 | 44.08        | 279.23                | 1.2                          |
| CD at 5% Among Test       |    | 11.07                | 9.27                 | 3.21            | 20.54                | 0.89                 | 21.22       | 53.72                  | 3.5                          |
| CD at 5% Test Vs Checks   |    | 8.19                 | 6.86                 | 2.38            | 15.20                 | 0.66                 | 15.71        | 39.53                  | 2.59                         |
| CV (%)                    |    | 6.31                 | 2.61                 | 18.18           | 16.26                 | 10.94                | 22.68       | 25.58                  |                             |

NS: Non significant; ** highly significant; * Significant; Values in parenthesis indicate the Probability value (Pr>F).

### Table 2c:  Descriptive statistics for quantitative characters of 328 genotypes screened for drought tolerance under control and KI treated conditions

| Characters                      | Max.  | Min.  | Range | Mean   | CV%  | SE(d) | CD among tests (0.05) |
|---------------------------------|-------|-------|-------|--------|------|-------|----------------------|
| Days to 50% flowering           | 68.80 | 68.77 | 36.6  | 34.17  | 54.92| 55.17 | 9.43                 |
| Days to full maturity           | 147.4 | 124.74| 99.94 | 98.34  | 118.16| 110.04| 9.16                 |
| 100-seed weight                 | 16.12 | 13.15 | 2.46  | 0.41   | 8.41 | 5.33  | 3.29                 |
| No. of pods per plant           | 174.4 | 145.11| 13.39 | 4.6    | 60.86| 37.1  | 21.52                |
| No. of seeds per pod            | 3.32  | 2.97  | 1.97  | 0.88   | 6.54 | 13.79 | 5.43                 |
| Plant height                    | 110.06| 96.83 | 32.44 | 32.4   | 72.96 | 60.66 | 29.24                |
| Row yield                       | 636.57| 351.37| 1.47  | 0.17   | 6.28 | 18.76 | 105.32               |
| Single plant yield              | 37.37 | 15.02 | 0.22  | 0.11   | 8.2  | 3.86  | 4.47                 |

C: control, T: treatment
### Table 3a: Analysis of variance for growth and yield parameters of germplasm lines grown under control conditions Kharif-2015

| Source of variation | df | Days to 50% flowering | Days to full maturity | 100-seed weight | No. of pods per plant | No. of seeds per pod | Plant height | Row yield | Single plant yield |
|---------------------|----|-----------------------|-----------------------|-----------------|-----------------------|---------------------|--------------|-----------|-------------------|
| Block               | 1  | 1.60NS (0.662)        | 1.877NS (0.350)       | 0.215NS (0.0018)| 187.06NS (0.058)     | 0.072NS (0.467)     | 7.91NS (0.135)| 0.008NS (0.921)| 3.66NS (0.126)   |
| Treatments          | 44 | 95.26** (<.0001)     | 131.64** (<.0001)     | 2.57** (<.0006) | 292.11** (<.0001)    | 0.2082NS (<.0736)   | 188.24** (<.0001)| 11668.13** (<.0001)| 12.86** (<.0001) |
| Error               | 44 | 8.25                  | 2.10                  | 0.94            | 49.61                 | 0.134               | 3.41         | 105.55    | 1.50              |
| CD at 5%            |    |                       |                       |                 |                       |                     |              |           |                   |
| CV (%)              |    | 5.58                  | 1.33                  | 12.36           | 17.02                 | 47.62               | 3.69         | 9.15      | 16.79             |

### Table 3b: Analysis of variance for growth and yield parameters of germplasm lines grown under KI treated conditions Kharif-2015

| Source of variation | df | Days to 50% flowering | Days to full maturity | 100-seed weight | No. of pods per plant | No. of seeds per pod | Plant height | Row yield | Single plant yield |
|---------------------|----|-----------------------|-----------------------|-----------------|-----------------------|---------------------|--------------|-----------|-------------------|
| Block               | 1  | 30.04NS (0.306)       | 6.94NS (0.691)        | 0.105NS (0.6108)| 4.32NS (0.712)        | 0.0393NS (0.2737)   | 153.83NS (0.0848)| 19.4063NS (0.7116)| 0.0003NS (0.982) |
| Treatments          | 44 | 98.29** (<.0001)     | 140.45** (<.0001)     | 2.92** (<.0001) | 126.74** (<.0001)     | 0.0913** (<.0001)   | 85.83** (<.0356) | 4414.41** (<.0001)| 6.233** (<.0001) |
| Error               | 44 | 28.08                 | 43.53                 | 0.399           | 31.47                 | 0.032               | 49.49        | 43.11     | 0.659             |
| CD at 5%            |    |                       |                       |                 |                       |                     |              |           |                   |
| CV (%)              |    | 10.68                 | 13.29                 | 1.27            | 11.30                 | 0.36                | 5.18         | 13.23     | 1.63              |
|                     |    | 10.32                 | 10.67                 | 12.72           | 24.55                 | 8.08                | 5.21         | 9.15      | 20.00             |
Table 4 Shannon-Weaver diversity indices for qualitative traits of the 328 germplasm accessions

| Sl. No. | Character            | H^I |
|---------|----------------------|-----|
| 1       | Growth habit         | 0.69|
| 2       | Leaf shape           | 0.25|
| 3       | Flower color         | 0.67|
| 4       | Pod color            | 0.21|
| 5       | Pod pubescence       | 0.13|
| 6       | Pubescence color     | 0.26|
| 7       | Seed Shape           | 0.69|
| 8       | Seed colour          | 1.2 |
| 9       | Seed lustre          | 0.69|
| 10      | Hilum colour         | 0.93|
| Average |                      | 0.57|

Table 4a Estimation of Principal component, Eigen value, proportional and cumulative percent variation for control block

| Component | Eigen Values | Variability % | Cumulative % |
|-----------|--------------|---------------|--------------|
| P_1       | 4.0985       | 51.2307       | 51.2307      |
| P_2       | 1.0853       | 13.5662       | 64.7969      |
| P_3       | 0.7750       | 9.6879        | 74.4848      |
| P_4       | 0.6151       | 7.6885        | 82.1733      |
| P_5       | 0.5142       | 6.4275        | 88.6008      |
| P_6       | 0.3798       | 4.7471        | 93.3479      |
| P_7       | 0.2868       | 3.5847        | 96.9325      |
| P_8       | 0.2454       | 3.0675        | 100.0000     |

Table 4b Estimation of Principal component, Eigen value, proportional and cumulative percent variation for Treatment block

| Component | Eigen Values | Variability % | Cumulative % |
|-----------|--------------|---------------|--------------|
| P_1       | 3.7417       | 46.7711       | 46.7711      |
| P_2       | 1.1953       | 14.9408       | 61.7119      |
| P_3       | 0.7926       | 9.9073        | 71.6193      |
| P_4       | 0.7169       | 8.9615        | 80.5808      |
| P_5       | 0.5665       | 7.0812        | 87.6620      |
| P_6       | 0.4199       | 5.2489        | 92.9109      |
| P_7       | 0.2989       | 3.7357        | 96.6466      |
| P_8       | 0.2683       | 3.3534        | 100.0000     |
**Table 5a** Estimation of percent contribution of traits for principal component in control block

| Characters                  | P<sub>1</sub> | P<sub>2</sub> | P<sub>3</sub> | P<sub>4</sub> | P<sub>5</sub> | P<sub>6</sub> | P<sub>7</sub> | P<sub>8</sub> |
|-----------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Days to 50%                 | 14.06         | 9.52          | 2.65          | 26.09         | 2.06          | 0.31          | 40.04         | 5.26          |
| Days to full maturity       | 15.39         | 1.93          | 7.83          | 22.96         | 0.00          | 1.70          | 40.06         | 10.12         |
| 100-seed weight             | 13.35         | 1.93          | 2.46          | 0.00          | 77.96         | 1.17          | 0.02          | 3.11          |
| No. of pods per plant       | 15.58         | 1.09          | 14.52         | 1.56          | 7.79          | 29.77         | 3.43          | 26.27         |
| No. of seeds per pod        | 8.11          | 3.57          | 60.42         | 23.89         | 0.00          | 2.40          | 1.09          | 0.51          |
| Plant height                | 0.36          | 80.12         | 0.27          | 16.95         | 1.23          | 0.02          | 1.05          | 0.00          |
| Row yield                   | 15.93         | 0.87          | 1.41          | 3.61          | 10.23         | 62.26         | 3.90          | 1.78          |
| Single plant yield          | 17.22         | 0.96          | 10.43         | 4.93          | 0.72          | 2.38          | 10.40         | 52.95         |

**Table 5b** Estimation of percent contribution of traits for principal component in treatment block

| Characters                  | P<sub>1</sub> | P<sub>2</sub> | P<sub>3</sub> | P<sub>4</sub> | P<sub>5</sub> | P<sub>6</sub> | P<sub>7</sub> | P<sub>8</sub> |
|-----------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Days to 50%                 | 12.87         | 18.08         | 0.00          | 13.90         | 13.22         | 3.63          | 32.26         | 6.04          |
| Days to full maturity       | 17.17         | 3.68          | 1.20          | 2.56          | 22.88         | 1.03          | 44.28         | 7.20          |
| 100-seed weight             | 10.14         | 2.05          | 2.17          | 68.43         | 13.64         | 0.36          | 3.09          | 0.13          |
| No. of pods per plant       | 18.29         | 1.31          | 1.37          | 0.47          | 14.85         | 19.94         | 2.12          | 41.66         |
| No. of seeds per pod        | 6.42          | 8.87          | 80.53         | 0.05          | 0.69          | 0.96          | 2.00          | 0.49          |
| Plant height                | 0.06          | 64.08         | 4.75          | 13.69         | 16.20         | 0.60          | 0.51          | 0.12          |
| Row yield                   | 16.30         | 0.59          | 7.43          | 0.83          | 5.42          | 66.00         | 3.24          | 0.18          |
| Single plant yield          | 18.75         | 1.34          | 2.55          | 0.07          | 13.10         | 7.48          | 12.50         | 44.20         |

**Table 5c** Loadings of principle component for PC1 and PC2

| Loadings                  | Control P<sub>1</sub> | Control P<sub>2</sub> | Treatment P<sub>1</sub> | Treatment P<sub>2</sub> |
|---------------------------|------------------------|------------------------|--------------------------|--------------------------|
| Days to 50%               | -0.759                 | 0.321                  | -0.694                   | 0.465                    |
| Days to full maturity     | -0.794                 | 0.145                  | -0.802                   | 0.210                    |
| 100-seed weight           | 0.740                  | 0.145                  | 0.616                    | 0.157                    |
| No. of pods per plant     | 0.799                  | 0.109                  | 0.827                    | 0.125                    |
| No. of seeds per pod      | 0.577                  | 0.197                  | 0.490                    | 0.326                    |
| Plant height              | -0.121                 | 0.933                  | -0.046                   | 0.875                    |
| Row yield                 | 0.808                  | 0.097                  | 0.781                    | 0.084                    |
| Single plant yield        | 0.840                  | 0.102                  | 0.838                    | 0.127                    |
**Table 6** Seed yield, seeds per plant, 100-seed weight and pods per plant of 328 soybean genotypes evaluated for terminal drought tolerance during Kharif-2014

| Characters               | Control                  |                     | Treatment               | Percent reduction due to KI spray |
|--------------------------|--------------------------|---------------------|-------------------------|---------------------------------|
|                          | Mean                     | Range               | CV%                     | Mean                            | Range | CV%   | Mean | Range |
| Seed yield (g/row)       | 175.57                   | 6.00 – 634.00       | 18.76                   | 67.88                           | 2.00 – 308.00 | 22.68 | 61.34 | 1.94 – 97.44 |
| Seed yield (g/plant)     | 8.86                     | 1.60 – 36.13        | 15.77                   | 4.26                            | 0 – 15.18     | 25.58 | 51.92 | 0.54 – 95.01 |
| 100-seed weight(g)       | 8.59                     | 2.50 – 16.20        | 11.99                   | 5.72                            | 0.35 – 12.56  | 18.18 | 33.41 | 0.62 – 96.67 |
| No. of pods/plant        | 62.10                    | 11.00 – 180.00      | 10.83                   | 40.54                           | 4.00 – 120.66 | 16.26 | 34.72 | 0.78 – 87.34 |

**Table 7** classification of germplasm lines based on the effect of KI spray on row yield and 100-seed weight under control and KI treated conditions during Kharif-2014

| Sl No. | Group                       | Germplasms         | Row yield (g)          | 100-seed weight(g) |
|--------|-----------------------------|--------------------|------------------------|--------------------|
|        |                             |                    | Control | KI treated | Control | KI treated |
| 1      | Tolerant (0 – 20%)          | TGX1835-3E         | 216.17   | 197.28 (8.74%)       | 10.54       | 9.72 (7.76%)       |
|        |                             | VSL-61             | 246.77   | 218.84(11.32%)       | 9.06       | 8.82 (2.65%)       |
|        |                             | EC-105790          | 248.37   | 223.74(9.92%)        | 10.33      | 9.24 (10.53%)      |
|        |                             | PK-1243            | 262.31   | 228.61 (12.85%)      | 9.09       | 7.58 (16.59%)      |
| 2      | Moderately tolerant (20.1 – 45%) | G-2130       | 90.17    | 53.47 (40.70%)       | 12.48      | 7.34 (41.17%)      |
|        |                             | DS-9802            | 122.17   | 83.74 (31.70%)       | 9.28       | 6.42 (30.80%)      |
|        |                             | SL-633             | 176.32   | 120.42 (31.70%)      | 10.69      | 6.71 (37.21%)      |
|        |                             | PKS-25             | 216.20   | 146.27 (32.35%)      | 11.37      | 8.11 (28.65%)      |
| 3      | Susceptible (45.1 – 85%)   | PK-1024            | 76.21    | 28.92 (62.04%)       | 12.97      | 6.25 (51.84%)      |
|        |                             | PK-1240            | 86.34    | 43.38 (49.76%)       | 7.79       | 2.35 (69.83%)      |
|        |                             | DS-2309            | 64.57    | 29.25 (54.70%)       | 12.86      | 4.01 (68.85%)      |
|        |                             | U SPL-291          | 81.54    | 33.81 (63.90%)       | 8.78       | 3.07 (65.08%)      |
Table 8 Seed yield, seeds per plant, 100-seed weight and pods per plant of four identified soybean genotypes evaluated for terminal drought tolerance using KI Kharif-2015

| Sl No. | Characters            | TGX1835-3E          | VSL-69          | EC-105780         | PK-1243          |
|--------|----------------------|---------------------|-----------------|------------------|-----------------|
|        |                      | Control             | KI              | Control          | KI              | Control         | KI              |
| 1      | Seed yield (g/row)   | 101.64              | 86.65 (14.75%)  | 108.45           | 93.46 (13.83%)  | 98.78           | 90.31 (8.57%)   | 109.73           | 91.96 (16.19%)  |
| 2      | Seed yield (g/plant) | 8.80                | 7.08 (19.59%)   | 7.78             | 6.34 (18.49%)   | 9.13            | 7.68 (15.79%)   | 10.47            | 8.46 (19.22%)   |
| 3      | 100-seed weight(g)   | 7.45                | 7.10 (4.70%)    | 5.20             | 4.90 (5.77%)    | 7.40            | 6.75 (8.78%)    | 6.40             | 5.78 (9.69%)    |
| 4      | No. of pods/plant    | 65.25               | 53.68 (17.73%)  | 61.10            | 51.37 (15.92%)  | 50.92           | 40.95 (19.57%)  | 51.70            | 42.72 (17.38%)  |

KI=potassium iodide
**Fig. 1a** Biplot of 328 soybean germplasm lines on PC1 and PC2 under controlled conditions Kharif-2014
Fig. 1b Biplot of 328 soybean germplasm lines on PC1 and PC2 under treated conditions Kharif-2014
In conclusion, drought is one of the most important factors responsible for the reduction of more than 50% seed yield in soybean. The occurrence of drought at terminal stage especially at seed filling to seed development in soybean is reported to cause severe yield loss. Drought tolerant genotypes have an inherent ability to increase source to sink mobilization of photosynthates under terminal drought conditions. KI spray at R₅ stage would imitate the terminal drought conditions and which is extensively tested in cereals and pulses as a defoliant and also mimics near drought like conditions under field conditions. Under KI treated conditions, the genotypes are placed well apart on a Biplot analysis and thus most lines have diverse expression towards KI spray, which shows that the lines were very divers in nature. In the present study, potassium iodide was applied at R₅ (seed filling) stage on a 328 germplasm lines to screen for terminal drought tolerance. Four genotypes (TGX1835-3E, VSL-69, EC-105780 and PK-1243) were identified as relatively tolerant as they showed least reduction for hundred seed weight and seed yield under KI induced drought over control. The identified genotypes were re-tested under similar conditions in next season. Based on two years testing, genotypes showing consistent behavior for drought tolerance were identified. Further studies by the authors will focus the molecular and physiological mechanisms involved in the drought tolerance in these lines for better utilization in breeding programmes.

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