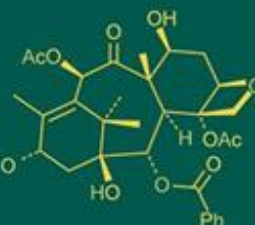
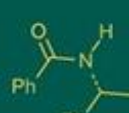
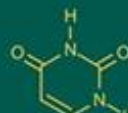
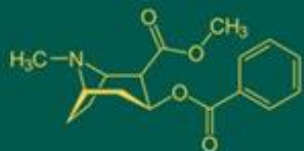


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Identification of stable genotypes in maize (*Zea Mays* L.) under stress situation

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Abstract

A field study was conducted during the kharif, rabi, and summer seasons of 2011–12, 2012–13, and 2013–14 to evaluate the stability of eight single-cross maize hybrids along with five commercial check hybrids (900M Gold, NK6240, Arjun, Bio-9681, and All Rounder) under drought stress conditions. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications across multiple environments. Combined analysis of variance revealed significant genotypic differences for nine agronomic and physiological traits across environments. Environmental effects were significant for most of the characters, indicating considerable variation among test environments. The genotype $\times$ environment ($G \times E$) interaction was non-significant for most traits, suggesting consistent performance of the hybrids across environments. The environmental linear component contributed significantly to the observed variation for most traits, whereas the $G \times E$ (linear) interaction remained nonsignificant. The pooled deviation, representing the non-linear component of the $G \times E$ interaction, was also non-significant for all characters except days to 50% anthesis, chlorophyll content at 90 days after sowing, and cob length. Stability analysis identified seven hybrids, namely CM-111 $\times$ NEI-9202B, HS-4 $\times$ NEI-9202B, 900M Gold, CI-4 $\times$ HS-4, HS-2 $\times$ NEI-9202B, HS-15 $\times$ HS-17, and KDMI-15 $\times$ NEI-9202B, as stable and widely adapted across different seasons and locations under drought stress. These hybrids exhibited consistent performance and may serve as promising genetic resources for the development of droughttolerant maize cultivars.

Keywords: *Zea Mays* L., drought stress, genotype $\times$ environment interaction, stability analysis, maize hybrids, adaptability, RCBD

Introduction

Maize (*Zea Mays* L.) is one of the most important cereal crops worldwide owing to its high yield potential, wide adaptability, and diverse end uses. Belonging to the family Poaceae and tribe Maydeae ($2n = 20$), maize originated in Central America and was domesticated approximately 9,000 years ago from its wild ancestor, teosinte (*Zea Mays* ssp. *parviglumis*). It is a monoecious, predominantly cross-pollinated, short-day plant with remarkable genetic diversity, making it one of the most extensively cultivated cereal crops across a wide range of agro-climatic conditions. Globally, maize serves as a staple food, livestock feed, and an important industrial raw material. It is utilized for human consumption, poultry and livestock feed, starch production, ethanol, biofuel, pharmaceuticals, and numerous value-added products. Specialized maize types, including Quality Protein Maize (QPM), sweet corn, baby corn, popcorn, and waxy corn, have further expanded its commercial and nutritional significance. Owing to its versatility and increasing industrial demand, maize continues to play a vital role in ensuring food, feed, and nutritional security.

According to recent estimates, maize is cultivated on approximately 199 million hectares worldwide, with an annual production of about 1.13 billion tonnes and an average productivity of 5.82 t ha^{-1} (Anonymous, 2024) [1]. In India, maize occupies nearly 12.84 million hectares, producing 46.15 million tonnes with an average productivity of 3.60 t ha^{-1} . Karnataka is one of the leading maize-producing states, cultivating the crop over approximately 1.90 million hectares, with a production of 6.35 million tonnes and an average productivity of 3.34 t ha^{-1} (Anonymous, 2025–26) [2].

Despite continuous genetic improvement, maize productivity is severely constrained by several abiotic stresses, particularly drought, which is considered the most important environmental factor limiting production in rainfed ecosystems. Since a major

proportion of tropical maize is cultivated under rainfed conditions, irregular rainfall and moisture stress during critical growth stages frequently result in significant yield losses. Drought affects plant growth by reducing photosynthesis, impairing nutrient uptake, disturbing reproductive development, and limiting grain filling, ultimately leading to reduced productivity (CIMMYT, 1999; Edmeades *et al.*, 2001) [3].

The development of drought-tolerant and widely adapted maize hybrids has therefore become a major objective of breeding programmes. However, the performance of a genotype is largely influenced by environmental conditions, resulting in genotype $\times$ environment ($G \times E$) interactions. Such interactions complicate the identification of superior genotypes because cultivar performance may vary considerably across locations and seasons. Therefore, evaluating hybrids under diverse environments is essential for identifying stable, high-yielding genotypes with broad or specific adaptation.

Yield stability is determined by the ability of a genotype to maintain consistent performance under varying environmental conditions, reflecting its genetic constitution (Borojević, 1990) [4]. Previous studies have indicated that heterozygosity contributes significantly to yield stability in maize improvement (Becker & Leon, 1988) [5]. Eberhart and Russell (1966) [6] developed one of the most widely accepted stability models, demonstrating that single-cross hybrids can combine high yield potential with broad adaptation across environments. Furthermore, Tollenaar and Lee (2002) [7] and Duvick *et al.* (2004) [8] reported that much of the genetic gain achieved in modern maize hybrids is attributable to improved tolerance to environmental stresses rather than increased yield potential under optimal conditions.

Assessment of phenotypic stability across multiple environments has become an integral component of maize breeding programmes. Stability analysis provides valuable information for selecting genotypes with consistent performance and identifying hybrids suitable for cultivation under stress-prone environments. Since grain yield and most agronomically important traits are quantitatively inherited and strongly influenced by environmental variation, multi-environment testing remains indispensable for evaluating genotype performance and understanding $G \times E$ interactions (Fan *et al.*, 2007) [9].

In this context, the present investigation was undertaken to identify stable maize (*Zea Mays L.*) hybrids under drought stress conditions using multi-environment evaluation. The study aimed to assess genotype $\times$ environment interactions and identify high-yielding, stable hybrids suitable for cultivation across diverse stress-prone environments, thereby contributing to the development of climate-resilient maize production systems.

Materials and Methods

The present investigation was conducted during the rabi and summer seasons of 2011–12, 2012–13, and 2013–14 at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, Karnataka, India. The experimental site is located at 15° 26' N latitude and 75° 07' E longitude, with an altitude of approximately 678 m above mean sea level. Meteorological data, including rainfall and minimum and maximum temperatures recorded during the crop growth period, were obtained from the observatory of the research station.

The experimental seasons experienced contrasting climatic conditions. During rabi 2011–12, the mean minimum and maximum temperatures ranged from 15.6 °C to 32.6 °C., with a total rainfall of 56.6 mm. During rabi 2012–13, temperatures varied between 15.7 °C and 29.2 °C, with 144.5 mm of rainfall. In summer 2013–14, the minimum and maximum temperatures ranged from 19.5 °C to 35.1 °C, and the total rainfall received was 178.4 mm. All experiments were conducted under managed moisture-stress conditions to evaluate the drought tolerance and stability of maize hybrids.

Eight experimental single-cross maize hybrids developed during kharif 2011 were evaluated along with five widely cultivated commercial check hybrids, namely 900M Gold, NK6240, Arjun, Bio-9681, and All Rounder. The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

The crop was sown on 14 December 2011, 12 October 2012, and 8 February 2013 for the respective evaluation seasons. Each genotype was planted in a four-row plot measuring 4 m in length, maintaining a spacing of 75 cm $\times$ 20 cm. Two seeds were dibbled manually per hill and later thinned to one healthy seedling per hill at 10–15 days after sowing to maintain the desired plant population.

All recommended agronomic and crop management practices were followed throughout the experimental period. To impose drought stress, irrigation was provided only up to 30 days after sowing, after which irrigation was withheld until harvest. This irrigation schedule ensured that the crop experienced moisture stress during the critical flowering and grain-filling stages.

Observations were recorded from five randomly selected competitive plants in each replication for each genotype. Data were collected on important morphological, physiological, and yield-related traits. The mean values of the five sampled plants were calculated and used for statistical and stability analyses.

Stability of the maize hybrids across environments was assessed using pooled analysis of variance and genotype $\times$ environment interaction analysis following the stability model proposed by Eberhart and Russell (1966) [6]. The analysis included estimation of the mean performance, regression coefficient (b_i), and deviation from regression (S^2di) to identify stable and widely adapted hybrids under moisture-stress conditions.

The list of experimental single-cross hybrids along with the commercial check hybrids evaluated in the study is presented below.

1	KDMI-15 X NEI-9202B	8	CI-4 X H S-4
2	NEI-9208B X H S-15	9	900M Gold
3	H S-4 X NEI-9202B	10	NK-6240
4	CI-4 X CML-446	11	Arjun
5	CM-111 X NEI-9202B	12	Bio-9681
6	H S-2 X NEI-9202B	13	Allrounder
7	H S-15 X H S-17		

Statistical analysis was carried out by Eberhart and Russell (1966) [6] in WINDOSTAT 8.0 software.

Results and discussion

Stability Analysis

The pooled analysis of variance (ANOVA) for stability parameters based on the model proposed by Eberhart and Russell (1966) [6] is presented in Table 1. The pooled genotypic effects across environments were highly significant for seven characters, namely days to 50% anthesis, days to 50% silking, anthesis-to-silking interval (ASI), chlorophyll content at 60 days after sowing, 100-seed weight, grain yield (kg ha^{-1}), and

shelling percentage, indicating the existence of substantial genetic variability among the evaluated hybrids.

Table 1: Pooled analysis of variance for stability analysis (Eberhart and Russell, 1966)^[6] for grain yield (kg/ha) in maize over three years under stress situation at College of Agriculture Dharwad

Sources of variation	df	Grain yield (kg/ha)
Rep within Env	6	2553327.00 **
Varieties	13	885331.30**
Env.+ (Var.* Env.)	28	22758.00*
Environments	2	3381587.00**
Var.* Env.	26	87463.48
Environments (Lin.)	1	6763173.00**
Var.* Env.(Lin.)	13	65963.56
Pooled Deviation	14	101180.30
Pooled Error	78	187925.80
Total	41	501134.90

Significant at 0.05 and 0.01 level of probability, respectively

Table 2: Environmental indices for grain yield (kg/ha) in maize over three years under stress situation at College of Agriculture Dharwad

Characters	Environmental index		
	Env. 1	Env. 2	Env. 3
Grain yield kg/ha	-281.23	-286.27	567.49

The environmental effects were significant for most of the traits, reflecting considerable differences among the test environments. However, environmental variance was nonsignificant for chlorophyll content at 60 days, plant height, ear height, number of kernel rows per cob, number of kernels per row, and shelling percentage. The genotype $\times$ environment ($G \times E$) interaction was significant for important traits including days to 50% anthesis, days to 50% silking, grain yield per plant, grain yield (kg ha^{-1}), 100-seed weight, and shelling percentage, suggesting differential responses of the genotypes under varying environmental conditions.

The environmental linear component contributed significantly to the variation observed for most of the characters, except plant height, ear height, number of kernel rows per cob, number of kernels per row, and shelling percentage. In contrast, the $G \times E$ (linear) interaction was non-significant for most traits, except 100-seed weight and shelling percentage, indicating that the performance of most hybrids remained relatively stable across environments. The pooled deviation (non-linear component of $G \times E$ interaction) was non-significant for all traits except relative water content at 90 days, number of cobs per plant, and number of kernels per row, suggesting that unpredictable environmental effects were generally minimal.

The three stability parameters mean performance ($\bar{y}$), regression coefficient (b_i), and $\bar{X}$ deviation from regression (S^2d_i) along with the environmental index were estimated for key traits, and the results are presented in Table 2.

Anthesis-to-Silking Interval (ASI)

The environmental index ranged from -0.167 to 0.286 , indicating considerable environmental variation over the three experimental years (Table 3). The hybrid NK6240 exhibited the longest anthesis-to-silking interval (2.89 days), whereas HS-15 $\times$ HS-17 recorded the shortest interval (1.44 days). The overall mean ASI across environments was 2.14 days.

Regression coefficients (b_i) and deviations from regression (S^2d_i) were non-significant for all hybrids except CM-111 $\times$ NEI-9202B, which showed a significant deviation from

regression, indicating unpredictable performance. The commercial check hybrids 900M Gold, NK6240,

Table 3: Stability parameters of single cross hybrids of maize for grain yield (kg/ha) in maize over three years under stress situation at College of Agriculture Dharwad

Genotypes / Varieties	Grain yield (kg/ha)		
	Mean	b_i	S^2d_i
KDMI-15 $\times$ NEI-9202B	4456.47*	0.51	-345332**
NEI-9208B $\times$ H S-15	3002.77	0.46	-7375
H S-4 $\times$ NEI-9202B	4008.20	0.75	-352507**
CI-4 $\times$ CML-446	2791.71	0.68	-354141
CM-111 $\times$ NEI-9202B	3806.28	0.93	-256331
H S-2 $\times$ NEI-9202B	4322.98	1.13	-220703
H S-15 $\times$ H S-17	4395.42	0.80	-352297**
CI-4 $\times$ H S-4	4263.73	1.39	-356815**
900M (check)	4120.05	1.42	-22069
NK-6240 (check)	3634.94	0.95	-338912
Arjun (check)	3647.86	1.28	-298403
Bio-9681 (check)	3710.98	1.12	-356482**
Allrounder (check)	3241.93	1.75	-54265
Population Mean	3753.69		

Significant at 5% probability level b_i – Regression coefficient

Significant at 1% probability level S^2d_i – Deviation from regression

Arjun, Bio-9681, and All Rounder recorded mean ASI values higher than the population mean while exhibiting regression coefficients close to unity and non-significant S^2d_i values, indicating stable performance across environments.

Number of Cobs per Plant

The environmental index for number of cobs per plant varied from -0.084 to 0.130 , reflecting moderate environmental variability. The overall mean number of cobs per plant across environments was 1.22. Among the hybrids, Bio-9681 produced the highest number of cobs per plant (1.33), whereas HS-15 $\times$ HS-17 recorded the lowest value (1.13).

None of the hybrids exhibited regression coefficients significantly different from unity, indicating average responsiveness to environmental changes. However, CI-4 $\times$ CML-446, NK6240, and Bio-9681 showed significant deviations from regression, suggesting inconsistent performance across environments. In contrast, NEI-9208B $\times$ HS-15 and CM-111 $\times$ NEI-9202B combined above-average mean performance with regression coefficients close to unity and non-significant S^2d_i values, indicating wide adaptability and stable performance.

Grain Yield

The environmental index for grain yield ranged from -286.27 to $567.49 \text{ kg ha}^{-1}$, indicating substantial environmental variation among the test environments. The average grain yield across all environments was $3753.69 \text{ kg ha}^{-1}$.

Among the evaluated hybrids, KDMI-15 $\times$ NEI-9202B recorded the highest mean grain yield ($4456.47 \text{ kg ha}^{-1}$), whereas CI-4 $\times$ CML-446 produced the lowest mean grain yield ($2791.71 \text{ kg ha}^{-1}$). All hybrids exhibited non-significant regression coefficients and deviations from regression, indicating relatively stable responses across environments.

Based on the stability parameters, the hybrids CM-111 $\times$ NEI-9202B, HS-4 $\times$ NEI-9202B, 900M Gold, CI-4 $\times$ HS-4, HS-2 $\times$ NEI-9202B, HS-15 $\times$ HS-17, and KDMI-15 $\times$ NEI-9202B exhibited mean grain yields above the population mean, regression coefficients close to unity, and non-significant deviations from regression. These hybrids may therefore be

considered stable and broadly adapted under moisture-stress conditions.

Drought Susceptibility Index (DSI)

The drought susceptibility index (DSI) values are presented in Table 4. Among the eight experimental single-cross hybrids and five commercial check hybrids, NEI-9208B × HS-15 recorded the highest DSI value (0.65), indicating greater susceptibility to drought stress. Conversely, HS-15 × HS-17 exhibited the lowest DSI value (0.26), demonstrating superior drought tolerance. The overall mean DSI across all genotypes was 0.44.

Table 4: Drought susceptibility index of 13F₁ hybrids for grain yield (kg/ha)

Hybrids	Drought susceptibility index
KDMI-15 X NEI-9202B	0.33
NEI-9208B X H S-15	0.65
H S-4 X NEI-9202B	0.44
CI-4 X CML-446	0.55
CM-111 X NEI-9202B	0.44
H S-2 X NEI-9202B	0.39
H S-15 X H S-17	0.26
CI-4 X H S-4	0.37
900M (check)	0.38
NK-6240 (check)	0.48
Arjun (check)	0.47
Bio-9681 (check)	0.43
Allrounder (check)	0.50
Mean	0.44

The lower DSI value of HS-15 × HS-17 suggests its greater ability to maintain grain yield under moisture-stress conditions, making it a promising hybrid for cultivation in drought-prone environments.

The significant genotype × environment (G × E) interactions observed for several traits necessitated the identification of stable genotypes with consistent performance across diverse environments. Stability analysis based on the model proposed by Eberhart and Russell (1966) [6] remains one of the most widely accepted approaches for evaluating genotype adaptability in maize and other field crops. According to this model, an ideal genotype is characterized by a high mean performance, a regression coefficient (bi) close to unity, and a non-significant deviation from regression (S²di), indicating predictable performance over varying environments. Similarly, Allard and Bradshaw (1964) [10] emphasized that stable genotypes are those exhibiting minimal interaction with environmental variation.

In the present investigation, genotype stability was assessed using three parameters: mean performance, regression coefficient (bi), and deviation from regression (S²di). The regression coefficient describes the responsiveness of a genotype to environmental changes. Genotypes with bi > 1 are considered more responsive and better adapted to favourable environments, whereas those with bi < 1 exhibit above-average stability and are more suitable for stress-prone or unfavourable environments. The deviation from regression (S²di) represents the unpredictable component of G × E interaction; therefore, genotypes with non-significant S²di values are considered more stable and predictable (Finlay and Wilkinson, 1963) [11].

For the anthesis-to-silking interval (ASI), HS-15 × HS-17 recorded the shortest interval, indicating greater synchrony

between male and female flowering under drought stress. Shorter ASI is a desirable trait in drought-prone environments because it enhances fertilization efficiency and kernel set. Hybrids such as CI-4 × CML-446, RMH-2, 900M Gold, Bio-9681, HS-15 × HS-17, Arjun, and NK6240 exhibited regression coefficients greater than unity, indicating better adaptation to favourable environments. These observations are in agreement with the findings of Arun and Singh (2004) [12], Kaundal and Sharma (2006) [13], Nagabhushan (2008) [14], and Vijaykumar (2008) [15].

For number of cobs per plant, the hybrids Arjun and HS-15 × HS-17 exhibited stable performance with regression coefficients close to unity and non-significant S²di values. Although Bio-9681 produced the highest number of cobs per plant, HS-15 × HS-17 showed greater stability across environments. Hybrids KDMI-15 × NEI-9202B, CI-4 × HS-4, 900M Gold, HS-4 × NEI-9202B, CI-4 × CML-446, and All Rounder were more responsive to favourable environments (bi > 1), whereas NEI-9208B × HS-15, RMH-2, HS-2 × NEI-9202B, and CM-111 × NEI-9202B exhibited regression coefficients less than unity with non-significant S²di values, indicating better adaptation to moisture-stress conditions. The significant S²di values observed for CI-4 × CML-446, NK6240, and Bio-9681 suggest relatively unpredictable performance across environments.

Grain yield stability revealed considerable variation among the evaluated hybrids. The hybrids CM-111 × NEI-9202B, HS-4 × NEI-9202B, 900M Gold, CI-4 × HS-4, HS-2 × NEI-9202B, HS-15 × HS-17, and KDMI-15 × NEI-9202B combined above-average grain yield with regression coefficients close to unity and non-significant deviations from regression, demonstrating wide adaptation and stable performance under moisture-stress environments. Among these, KDMI-15 × NEI-9202B recorded the highest mean grain yield, whereas CI-4 × CML-446 produced the lowest. Similar findings have been reported by Satyanarayan and Kumar (1995), Machado *et al.* (2008) [16], Romay *et al.* (2010) [17], Kuchanur (2010) [18], Lata *et al.* (2011) [19], Ijaz-Ul-Hassan *et al.* (2011) [20], Badu-Apraku and Oyekunle (2012) [21], Khalil (2013) [22], and Paulo Roberto *et al.* (2014) [23], who also reported superior yield stability in elite maize hybrids across diverse environments.

The drought susceptibility index (DSI) further confirmed the superiority of HS-15 × HS-17, which recorded the lowest DSI value, indicating greater tolerance to moisture stress. Lower DSI values reflect a genotype's ability to maintain grain yield under drought conditions and are therefore considered an important criterion for selecting drought-tolerant hybrids. Similar observations have been reported by Kuchanur (2010) [18], Majid *et al.* (2010) [24], Lata *et al.* (2011) [19], Ijaz-Ul-Hassan *et al.* (2011) [20], Badu-Apraku and Oyekunle (2012) [21], Khalil (2013) [22], and Paulo Roberto *et al.* (2014) [23].

Conclusion

Based on stability parameters and drought susceptibility analysis, seven hybrids CM-111 × NEI-9202B, HS-4 × NEI-9202B, 900M Gold, CI-4 × HS-4, HS-2 × NEI-9202B, HS-15 × HS-17, and KDMI-15 × NEI-9202B demonstrated stable performance across seasons and environments under moisture-stress conditions. These hybrids combined high grain yield, broad adaptability, and predictable performance, making them promising candidates for cultivation in drought-prone regions and valuable genetic resources for future maize breeding programmes aimed at improving drought tolerance and yield stability.

References

1. Anonymous. <https://indiastat.com>. 2024.
2. Anonymous. <https://indiastat.com>. 2025-2026.
3. Edmeades GO, Cooper M, Lafitte R, Zinselmeier C, Ribaut JM, Habben JE, *et al.* Abiotic stress and staple crops. In: Nosberger J, Geiger HH, Struic PC, eds. Crop science: Progress and Prospects. Proc. of Third Int. Crop Sci. Congress. Wallingford, Oxon, U. K.: CAB Int.; 2001:137-154.
4. Borojevic S. Principles and Methods of Plant Breeding. Developments in Crop Science Vol.17. New York: Elsevier science Publishing Company INC; 1990.
5. Becker HC, Léon J. Stability analysis in plant breeding. Plant Breed. 1988;101(1):1-23.
6. Eberhart SA, Russell WA. Stability parameters for comparing varieties. Crop Sci. 1966;6:36-40.
7. Tollenaar M, Lee EA. Yield potential, yield stability and stress tolerance in maize. Field Crops Res. 2002;75(2):161-169.
8. Duvick DN, Smith JCS, Cooper M. Long-term selection in a commercial hybrid maize breeding program. In: Janick J, ed. Plant breeding reviews: longterm selection: crops, animals, and bacteria, Vol. 24, Part 2. New York: John Wiley & Sons; 2004:109-151.
9. Fan XM, Kang MS, Chen H, Zhang Y, Tan J, Xu C. Yield stability of maize hybrids evaluated in multi-environment trials in Yunnan, China. Agron. J. 2007;99:220-228.
10. Allard RW, Bradshaw AD. Implication of genotype x environmental interaction in applied plant breeding. Crop Sci. 1964;4:503-505.
11. Finlay KW, Wilkinson GN. Analysis of adaptation in plant breeding programme. Aust. J. Agric. Res. 1963;14:742-754.
12. Arun kumar, Singh NN. Stability studies of inbred and single crosses in maize. Ann. Agric. Res. 2004b;25:142-148.
13. Kaundal R, Sharma BK. Genotype x environment interaction and stability analysis for yield and other quantitative traits in maize (*Zea Mays* L.) under rainfed and high rainfall valley areas of the submontane. Res. Crop. 2006;7(1):171-180.
14. Nagabhushan. Relative stability analysis of public and private bred hybrids of maize (*Zea Mays* L.). MSc Thesis submitted to University of Agricultural Sciences, Dharwad, Karnataka (India). 2008.
15. Vijaykumar. Stability analysis of maize (*Zea Mays* L.) inbred lines/introductions for yield parameters. MSc Thesis, Univ. Agril. Sci., Dharwad, Karnataka (India). 2008.
16. Machado JC, Souza JC, Ramalho AP, Lima JL. Yield stability in single and double crosses of maize originated from the same gene pool. Bragantia. 2008;67(3):627-631.
17. Romay MC, Malvar RA, Campo L, Alvarez A, Gonzalez JM, Ordas A, *et al.* Climatic and genotypic effects for grain yield in maize under stress conditions. Crop Sci. 2010;50(1):51-58.
18. Kuchanur PH. Identification of drought tolerance maize (*Zea Mays* L.) germplasm. Ph.D. Thesis, Univ. Agril. Sci., Dharwad, Karnataka (India). 2010.
19. Lata SS, Guleria JD, Katna G, Sood BC, Kalia V, Anand Singh. Stability analysis in maize (*Zea Mays* L.) hybrids across locations. Electronic J. Pl. Breed. 2011;1(3):239-243.
20. Ijaz-Ul-Hassan S, Tariq M, Islam N. Assessment of newly developed maize single cross hybrids in two seasonal regimes. J. Agric. Soc. Sci. 2011;7:139-142.
21. Badu BA, Oyekuncle H. Genetic analysis of grain yield and other traits of extraearly yellow maize inbred lines and hybrid performance under contrasting environments. Field Crops Res. 2012;129:99-110.
22. Khalil MAG. Stability Analysis for Promising Yellow Maize Hybrids under different locations. Alex J. Agric. Res. 2013;58(3):279-286.
23. Paulo RDS, Dilson AB, Ana BL, Lindolfo S. Adaptability and stability of corn hybrids grown for high grain yield. Acta Scientiarum. 2014;36(2):175-181.
24. Majid S, Rajab C, Eslam M, Farokh D. Estimation of combining ability and gene action in maize using line x tester method under three irrigation regimes. J. Res. Agric. Sci. 2010;6:19-28.
25. Joshi P, Mane M. Effectiveness of the Slump Test in Diagnosing and Managing Lower Back Pain in Fast Bowlers: A Study on Rehabilitation outcomes. Social Science Reports. 2026. <https://doi.org/10.51470/SSR.2026.10.01.106>
26. Sangamwar BS, Bele AS, Telkhade PM. Study of Chemical Fertilizers and Pesticides Consumption in Mul Region, District Chandrapur. Life Science Review. 2026;10(1):23-26. <https://doi.org/10.51470/LSR.2026.10.01.23>
27. Yunusa MA, Dandago MA. Perspectives on Post-Harvest and Storage Technologies for Legume Crops: A Review. Life Science Review. 2026;10(1). <https://doi.org/10.51470/LSR.2026.10.01.33>
28. Eboh AS, Wodu E. Gas Chromatography Flame Ionization Detection of Alkaloids, Phytochemicals, Antimicrobial and Antifungal Potential of *Ageratum conyzoides* Leaf Extract: *In vitro* and *In Silico* Studies. Life Science Review. 2026;10(1). <https://doi.org/10.51470/LSR.2026.10.01.95>
29. Nutritional and Antinutritional Factors in Underutilized Legumes: Occurrence, Nutritional Implications and Mitigation Strategies. Life Science Review. 2026;10(1).
30. Natural Products as Sources of Therapeutic Agents and Functional Biomolecules. Life Science Review. 2025;9(2):40-45.
31. Landge GV, Raut GS, Panghate SD, Kale DP, Shinde SS, Narwade KB. Evaluating Environmental Awareness, Attitudes and Perceptions of Urban Residents for Sustainable Environmental Management in Chandrapur District (MS), India. Life Science Review. 2025;9(1):1-7. <https://doi.org/10.51470/LSR.2025.09.01.01>
32. Microscopic Characterization and Preliminary Pharmacognostical Evaluation of *Cryptocoryne retropiralis* Roxb. Kunth. Life Science Review. 2025;9(1):21-28. <https://doi.org/10.51470/LSR.2025.09.01.21>
33. Balancing Water and Nutrients: The Future of Integrated Fertigation Systems. Life Science Review. 2025.
34. Smart Farming Starts Below the Surface: The Power of Soil and Moisture Sensors. Life Science Review. 2025.
35. Life Science Review (LSR). Archives. CRC Journals. Available from: Life Science Review Archives
36. Satyanarana E, Kumar RS. Phenotypic stability studies for grain and straw yields in maize composites. J. Maharashtra Agric. Univ. 1995;20:225-226.
37. Yadav OP, Karjagi CG, Kumar B, Jat SL, Chawla JS, Kaul J, *et al.* Maize improvement in India. 12th Asian Maize Conference and Expert Consultation on Maize for Food,

Feed, Nutrition and Environmental Security 30 Oct– 1 Nov 2014 Bangkok, Thailand. 2014:263-273.

38. Table 2: Environmental indices for grain yield (kg/ha) in maize over three years under stress situation at College of Agriculture Dharwad

39. Appendix I: Mean monthly meteorological data during 2011, 2012, 2013 and 2014 (experimental years) of Main Agricultural Research Station, Dharwad. *n.d.*

Appendix I: Mean Monthly Meteorological Data During 2011, 2012, 2013, and 2014 (Experimental Years) at the Main Agricultural Research Station, Dharwad

Month	Rainfall (mm)				Temperature (°C)								Relative humidity (%)			
					Mean maximum				Mean minimum							
	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014	2011	2012	2013	2014
January	1.0	0.0	0.0	0.0	29.2	29.8	31.2	29.5	12.6	14	14.5	14.7	60.1	55.5	47.0	
February	21.6	0.0	2.2	0.0	30.8	32.3	32.6	31.1	14.0	15.9	16.8	16.1	48.5	53.4	51.0	
March	0.8	0.0	42.0	11.4	35.2	35.8	35.3	34.5	18.6	15.9	19.2	18.5	43.9	40.7	48.0	
April	78.0	56.6	10.0		34.9	35.7	36.9		20.2	18.4	20.2		55.7	57.1	51.0	
May	66.6	3.8	124.2		34.7	35.6	35.5		21.3	21.2	21.8		61.6	50.8	61.0	
June	194.0	43.4	75.4		27.5	30.6	28.0		21.3	21.5	20.8		83.8	73.7	82.0	
July	133.0	112.2	170.2		26.9	27.2	25.4		20.6	20.9	20.3		85.8	84.6	89.0	
August	124.2	90.0	98.4		26.7	32	26.7		20.7	19.3	19.9		86.7	80.4	85.0	
September	82.8	89.6	133.6		28.1	28	27.9		19.9	19.8	20.2		79.7	75.8	81.0	
October	219.7	89.2	75.6		29.9	28.4	28.8		19.5	17.8	19.4		73.6	64.7	76.0	
November	4.6	35.7	2.2		29.8	27.7	29.0		15.8	15.5	15.8		55.9	57.7	64.0	
December	0.0	19.6	0.0		29.5	29.5	28.4		13.8	14.8	14.7		56.3	55.9	56.1	
Total	926.3	540.1	733.8	11.4	-	-	-	-	-	-	-	-	-	-	-	-