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NEW APPROACH FOR SELECTION OF HIGH YIELD AND STABLE EXOTIC AND INDIGENOUS PROMISING LINE IN QUINOA (*Chenopodium quinoa*)

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ABSTRACT

Multi-location trials (MLT) play a crucial role in crop improvement initiatives by identifying the potential promising lines across various locations prior to their release as a variety. The aim of this research was to identify Quinoa promising lines that demonstrate elevated grain yield and reliable performance across various locations across the India.

The study utilized a set of 13 quinoa potential promising lines that underwent multi-location grain yield trials over a three-year period from 2019 to 2021 at eight different sites. To test the significance of the promising lines × location (PL) interaction and also to perform a stability analysis using eight parametric measures, we aimed to identify promising line that exhibit stable and high yields across the eight locations. A novel Combined Stability Index was developed to evaluate yield stability, which was determined by ranking the stability measures used for all the promising lines.

Based on a low combined stability index, IC411825, EC507748, EC507744, EC507747 have been recognized as the promising lines with the greatest stability with significant yield potential. These parametric evaluations appeared to correlate with higher grain yield. To evaluate the relationship between the eight stability statistics and average grain yield, the simple rank correlation coefficient was determined by using their ranks. The relationships among the parametric measures were analyzed, leading to the categorization of these stability metrics into three groups. The promising line EC507744 belong to section 1, identified as the most promising due to their high grain yield coupled with exceptional stability performance, as indicated by the plot of all parametric metrics against grain yield. EC507744, which exhibited a greater grain yield (16.42 q/ha) along with a high protein content (13.01%) and better stability across different locations, could be utilized in future breeding programs for Quinoa and is recommended for variety release in the plains of India.

***Key words*:** Combined stability index, Location interaction, statistical measures, sustainability index, general adaptability index, quinoa

Introduction

Extreme drought and floods occurrences are predicted to rise as a result of climate change because of altered rainfall patterns. Ecosystems suffer more from these extreme occurrences than from variations in the yearly mean precipitation. Additionally, it is predicted that temperatures will rise, which would lead to increased rates of water evaporation, further increasing dry zones and salinizing crop soils. Since water availability is the most crucial element in plant development, plants thrive on soils afflicted by drought and salinity, which lowers agricultural productivity. Additionally, as the nation's

population grows, agricultural output must rise to meet the rising need for food. In order to sustain or boost agricultural output, the research community is attempting to investigate species or kinds that are more resilient to salinity or water scarcity, as there is no longer any possibility of expanding the overall agricultural area.

Native to Latin America, quinoa (*Chenopodium quinoa*) has been designated a crop for food and nutritional security by the Food and Agricultural Organization due to its high nutritional content and ability to adapt to harsh weather, climate, and soil conditions. In addition, the crop's demand peaked recently on a global scale. The suitability of the crop in the area was therefore assessed over the last ten years, i.e., 2014–15 and 2023–24, at multilocation under the AICRN on Potential Crops, in order to increase the benefits of agriculture for the farmers in India's water-scarce zones. Water scare zone and marginal soils, where no other crop can be cultivated, farmers will find information on crop production technologies and management techniques, as well as their application, advantages, and market potential, useful. Due to its higher protein content and lower carbohydrate content than rice, quinoa farming has a promising future in India.

The utilization of quinoa as a new source for high protein and mineral has tremendous scope in contributing to the growing needs of nutritional resources in the country. Nevertheless, several inquiries exist regarding its production, marketing, and genetic enhancement in India. No work has been taken up on genetic improvement and location interaction of this quinoa so far in India. At global level information on genetic improvement, adaptability and promising line-location interactions of quinoa is restricted to few publications. The aim of this research was to comprehend the extent of genetic diversity, promising line - location interaction and its adaptability in quinoa to identify the best promising line to the utilize for future genetic improvement work.

To increase and stabilize the production and productivity, identification of adoptable lines with high yield potential are of paramount importance. Stability analysis helps in understanding the varietal adaptation under variable location. Thus, use of highly adaptable varieties is important in stabilizing productivity over seasons and regions.

Keeping this in view, the present investigation "Yield stability promising lines selection in quinoa" was conducted to know: (i) the extent of promising line x location interaction in different promising lines, (ii) identify the best promising line giving stable yield over the locations and (ii) study relationship and similarities among different statistical parameters used to assess the stability.

Table 1: Code, promising line name and source (Raiger *et al*., 2021).

Code	Promising line name	Origin/source Country
G-1	EC-507743	USA
G-2	EC-507748	Argentina
G-3	EC-507746	Peru
G-4	EC-507738	Peru
G-5	EC-507749	USA
G-6	EC-507747	Argentina
G-7	EC-507739	Ecuador
G-8	EC-507744	USA
G-9	EC-507741	USA
G-10	EC-507740	USA
G-11	EC-507742	Chile
G-12	IC-411824	Jammu & Kashmir, India
G-13	IC- 411825	Jammu & Kashmir, India

Materials and Methods

Experimental design and plant materials

During rabi 2017-18, twenty-five accessions of quinoa of diverse origin were grown in Augmented Block Design (Federer, 1956) with ten blocks. Each block contained ten entries and three checks. The experiment was repeated at 3 locations, namely, Bhubaneswar, Ludhiana and SK Nagar. The grain yield was recorded on plot basis. The top achievers promising line, based on average grain yield over locations 13 promising lines (11 exotic and indigenous 2) (Table 1) were grown during rabi 2019-21. The experiment was designed using a Randomized Block Design, consisting of three replications across eight test locations (Table 2) of AICRN on Potential Crops namely, IGKV, Ambikapur; ANDAUT, Ayodhya; UAS, Bengaluru; OUAT, Bhubaneswar; CCS HAU, Hisar; PAU, Ludhiana; MPKV, Rahuri and SDAU, SK Nagar. The plot size was 3.6 m^2 with row to row distance of 45 cm and plant to plant distance of 15 cm at all the locations. Grain yield for each promising line was determined at harvest at each location. For stability analysis, yield data from 8 locations was considered (Raiger *et al.*, 2021).

Statistical Analysis

Test of significance: For the original data sets, variances for promising line (P), location (L), and the interaction between promising line and location (PL) were computed through combined analysis of variance (ANOVA). The significance of statistical tests was evaluated using F-tests.

Statistical measures

Regression approach: There were two components

Table 2: Agro-climatic characteristics of eight locations.

Location	Latitude	Longitude	Altitude (m)	Soil Texture
Ambikapur	23°12'N	83°02' E	623	Sandy loam
Ayodhya	26.7961° N	82.2051° E	93	Primarily sandy loam
Bengaluru	12.97° N	77.56° E	920	Sandy clay loam
Bhubaneswar	20.296059° N	85.824539° E	45	Sandy loam
Hisar	29.17 N	75.72 E	215	Sandy loam
Ludhiana	30.9010° N	75.8573° E	262	Predominantly sandy loam
Rahuri	19.3951° N	74.6521° E	511	Silty clay
SK Nagar	26.7672° N	83.0361° E	68	Primarily alluvial soil

to the interaction sum of squares between promising lines and sites. According to the approach suggested by Eberhart and Russell (1966) to evaluate the promising lines reaction to location changes, one portion reflected the heterogeneity of the linear regression coefficient (bi), and the second part represented the pooled deviation from individual regression line (S_{di}^2). Here the promising line response to location changes was estimated as under:

$$b_i = 1 + \frac{\sum_j \left(X_{ij} - \bar{X}i. - \bar{X}.j + \bar{X}..\right)\left(\bar{X}.j - \bar{X}..\right)}{\sum_j \left(\bar{X}.j - \bar{X}..\right)^2}$$

$$S_{di}^2 = \frac{1}{s-2}\left[\sum_j \left(X_{ij} - \bar{X}i. - \bar{X}.j + \bar{X}..\right)^2 - (bi-1)^2 \sum_j \left(\bar{X}.j - \bar{X}..\right)^2\right] - \bar{S}_e^2$$

Where,

X_{ij} is grain yield of quinoa for i[th] promising line in j[th] location, $\bar{X}i.$ is the mean grain yield for i[th] promising line, $\bar{X}.j$ is the average yield of j[th] location, $\bar{X}..$ is the grand mean, the error variance ($\bar{S}_e^2$) and number of locations (s) are given in formula.

The regression coefficient's (bi) magnitude was used to classify the performance of promising lines. High yield and regression coefficient (>1) of promising lines were considered suitable for favourable locations, the promising lines with regression coefficient <1 and high yield were considered suitable for unfavourable locations and the promising lines with regression coefficient equal to 1 and having high yield were adapted to all locations. The promising lines with minimum deviation from regression (S_{di}^2 being almost equal to 0) were most stable.

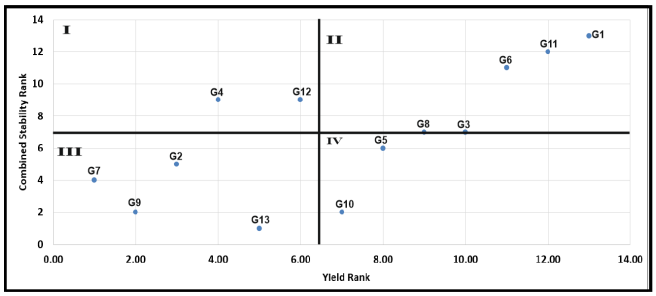


Fig. 1: The combine stability index rank against mean grain yield rank of quinoa promising line over location.

Location variance (S_{ti}^2): One of the key stability measures is the location variance (Lin *et al.*, 1986) and for every promising line across the test locations, location variance was computed. A promising line with minimum variance under different locations was considered to be stable. The following formula was used to calculate this measure:

$$S_{ti}^2 = \frac{\sum_j \left(X_{ij} - \bar{X}i.\right)^2}{(s-1)}$$

Where,

X_{ij} is the grain grain yield of i[th] promising line in j[th] location, $\bar{X}i.$ is the mean grain yield of i[th] promising line and s is the number of locations.

Superiority index (PI): The superiority index (PI) provides an estimate of how well a promising line can adapt or perform in various locations. It is determined by using the promising line with the highest seed yield in each location as a benchmark. The promising line that exhibits the greatest yield variation when compared to the reference promising line would have the highest P_i value. (Lin and Binns, 1988), but the stable promising line will have a lower P_i value.

$$P_i = \frac{\sum_j \left(X_{ij} - M_e\right)^2}{2s}$$

Where,

X_{ij} is the grain yield of the i[th] promising line in j[th] location, M_e is the grain yield of the promising line with

Table 3: Joint variance analysis of seed yield among 13 promising lines evaluated across 8 different locations.

Source	d.f.	MS
Promising lines (P)	12.00	9.64*
Within Promising lines	91.00	22.81**
Location (linear)	1.00	1525.33
P×L (linear)	12.00	4.78
Pooled deviation	78.00	6.32**
Average Error	192.00	0.93
*p < 0.05; **p < 0.01		

Table 5: Statistical measures and grain yield of 13 promising lines tested in 8 locations in quinoa.

S. no.	Promising line code	Yield mean (q/ha)	Protein	*Sti*²	*PI*	*Wi*²	*GAI*	*CV*	bi	*Sdi*²	*SI*
1.	EC507738	12.61	13.01	23.62	18.01	84.65	11.22	38.54	0.84	81.78	46.88
2.	EC507739	15.43	13.89	27.53	52.12	45.37	14.68	34.01	1.13	43.45	41.76
3.	EC507740	13.75	14.77	17.83	29.74	22.36	13.12	30.72	0.94	21.89	46.75
4.	EC507741	15.24	14.76	30.33	37.30	62.17	14.12	36.13	1.14	59.88	43.90
5.	EC507742	14.08	14.01	20.09	33.49	19.84	13.42	31.83	1.01	19.82	45.47
6.	EC507743	13.48	13.01	27.13	31.57	39.58	12.48	38.65	1.14	37.26	41.86
7.	EC507744	16.42	14.91	10.45	18.04	76.05	16.16	19.69	0.49	45.24	61.02
8.	EC507746	13.80	13.81	13.05	23.48	17.58	13.36	26.17	0.81	13.53	51.56
9.	EC507747	15.63	13.57	31.96	47.10	52.73	14.74	36.18	1.23	46.60	41.97
10.	EC507748	14.09	13.65	17.43	22.43	16.75	13.50	29.63	0.95	16.44	50.77
11.	EC507749	13.23	14.70	22.40	25.97	39.51	12.45	35.77	1.00	39.51	44.92
12.	IC411824	14.73	14.26	30.52	42.50	51.82	13.69	37.49	1.19	47.60	41.17
13	IC411825	15.18	15.64	24.19	28.78	22.00	14.39	32.40	1.13	20.08	48.37

* Significant at $p < 0.05$; ** Significant at $p < 0.01$ and bold values indicate stability of the promising line

maximum yield at j^{th} location and number of locations (s).

Wricke's ecovalence (W_i^2): The Wricke's (1962) ecovalence is normally used for promising line interaction assessment. However, it was used here for estimating promising line x location interaction as under:

$$W_i^2 = \sum_j \left(X_{ij} - \bar{X}i. - \bar{X}.j + \bar{X}..\right)^2$$

Where,

X_{ij} is the observed yield of ith promising line in j^{th} location (average value across replications), $\bar{X}i.$ and $\bar{X}.j$ correspond to mean of ith promising line jth location respectively, and $\bar{X}..$ is the grand mean. Greatest stability is when $W_i^2 = 0$.

***Coefficient of variance* (*CV*)**: This stability parameter, as usual, is measured by use of following formula.

$$CV_i = \frac{\sqrt{\sum \left(Xij - Xi.\right)^2 / n}}{\bar{X}i.} \times 100$$

Promising line showing a low coefficient of variation and high average yields were considered the most favorable

***Geometric adaptability index (GAI)*:** In this case, the geometric mean is used to estimate adaptability and suitability of the promising lines (Mohammadi and Amri, 2008) and is calculated as below:

$$GAI_i = \sqrt[s]{\left(X_{i1}\right)\left(X_{i2}\right).....\left(X_{is}\right)}$$

Where,

X_{ij} grain yield of i^{th} promising line and jth location and s is number of locations. The promising lines with high GAI will be desirable.

Sustainability index (SI): The sustainability indices were estimated by using the following formula (Gangwar *et al.*, 2004). It signifies that the promising line with high *SI* will be favorable.

$$SI = \frac{\bar{X}i. - \sigma n}{M_e} \times 100$$

Table 6: Rank correlations among mean grain yield and eight statistical parameters of 12 promising lines.

	Mean	*Sti2*	*PI*	*Wi2*	*GAI*	*CV*	*bi*	*Sdi2*	*SI*
Mean	1								
Sti2	0.124	1							
PI	-0.124	0.747**	1						
Wi2	-0.069	0.442	0.07	1					
GAI	0.995**	0.14	-0.102	-0.033	1				
CV	0.424	0.831**	0.401	0.517	0.44	1			
bi	0.085	0.917**	0.846**	0.178	0.096	0.709**	1		
Sdi2	-0.03	0.552	0.147	0.972**	0.011	0.605*	0.282	1	
SI	-0.049	0.663*	0.669*	0.264	-0.022	0.677*	0.669*	0.363	1

*$p < 0.05$; **$p < 0.01$

Table 7: Estimated Combined Stability Index of quinoa Promising line.

S. No.	Promising lines	Rank of Yield and Stability Measures									M	FQ	SD	RSD	CSI
		Mean	*Sti*^{2}	*PI*	*Wi*^{2}	*GAI*	*CV*	bi	*Sdi*^{2}	*SI*					
1	EC507738	13	7	1	13	13	12	3	13	5	13	2	4.91	13	41
2	EC507739	3	10	13	8	3	7	9	8	12	3	5	3.48	11	22
3	EC507740	10	4	7	5	10	4	4	5	6	4	5	2.42	5	24
4	EC507741	4	11	10	11	5	9	10	12	9	11	2	2.74	8	25
5	EC507742	8	5	9	3	8	5	7	3	7	8	4	2.20	3	23
6	EC507743	11	9	8	7	11	13	11	6	11	11	0	2.29	4	26
7	EC507744	1	1	2	12	1	1	1	9	1	1	7	4.21	12	21
8	EC507746	9	2	4	2	9	2	2	1	2	2	7	3.12	10	28
9	EC507747	2	1	2	4	2	4	1	4	10	2	8	2.78	9	21
10	EC507748	7	3	3	1	7	3	5	2	3	3	7	2.11	2	19
11	EC507749	12	6	5	6	12	8	6	7	8	6	1	2.59	7	26
12	IC411824	6	12	11	9	6	11	12	11	13	11	0	2.57	6	23
13	IC411825	5	8	6	4	4	6	8	4	4	4	5	1.67	1	15
Correlation with rank mean grain yield		1	0.124	-0.124	-0.069	0.995**	0.424	0.085	-0.03	-0.049					

M: Mode; FQ: Frequence; Sd: $SD_{(i)}$; RSD: Rank of $Sd_{(i)}$; CSI: ($CSI_{(i)}$)

Where,

$\bar{X}i.$ is the average performance of ith promising line across the locations, σn is the standard deviation and M_e best performance of the ith promising line across locations.

Spearman's rank correlation was used to determine the relationship between these statistical characteristics (Spearman, 1904). Three categories have been presented in order to comprehend the link between these measures. Measures that are positively and significantly correlated with mean grain yield fall into category I; those that are positively and non-significantly connected fall into category II; and those that are adversely correlated with mean grain yield fall into category III.

Combined stability index of promising line

A novel method that evaluates yield stability performance through the ranking of stability measures for all promising lines is suggested (Raiger *et al.*, 2023). t promising lines having performance of stability measure K are ranked. CSI(i) of ith promising line is the sum of rank of mean yield of ith cultivar (RYi), rank of mean rank of stability measures of ith promising line and rank of standard deviation ($RSd_{(i)}$) of stability measures. A low combined stability index value is regarded as an indication of the most stable and high-yielding potential promising lines

$$Sd(i) = \sqrt{\frac{\sum_{j=1}^{k}(R_{ij}-\bar{R}_i)^2}{k-1}}$$

$$CSI_{(I)} = RY_i + R_i + RSd^{(i)}$$

Statistical packages

Stability parameter was analysed by using MS-excel (2007), R, SPSS and SAS software.

Results and Discussion

The joint analysis of variance for seed yield across various locations is shown in Table 3. The variances attributed to locations, promising lines, and their interactions were all highly significant ($p<0.01$). The average yield of the cultivar at different sites over the three years (Table 4) also demonstrated considerable variation in yield across locations and years, highlighting the presence of promising line × location interactions. In these circumstances, it is challenging to determine the most appropriate cultivar solely from the average performance, making the estimation of stability parameters crucial. Nonetheless, according to the average performance (as shown in Table 5), promising lines EC507744, EC507746, EC507748 and EC507747 outperformed the other promising lines.

As per the statistical parameter bi, the promising lines IC411825, EC507739, EC507741, EC507743, IC411824 and EC507747 with high yield and regression coefficient (bi) higher than 1 were most suitable to favorable locations, whereas promising line EC507740, EC507748, EC507749 and EC507742 with high grain yield and $bi \approx 1.0$ could be considered as suitable for all the locations. Promising lines EC507744, EC507746 and EC507738 with $bi < 1$ and good grain yield were well adapted to poor locations. The promising line EC507748 with higher mean grain yield and regression coefficient being equivalent to 1 had low deviation from regression also. Therefore, these

Table 8: Identify promising line based on stability statistics and high grain yield.

S. No.	Statistics	Stable promising lines and high yield
1	**Mean (q ha^{-1})**	EC507744, EC507747, EC507739, EC507741, IC411825
2	***Sti*^{2}**	EC507744, EC507747, EC507746, EC507748, EC507740, EC507742
3	*PI*	EC507738, EC507744, EC507747, EC507748, EC507746, EC507749
4	*Wi*^{2}	EC507748, EC507746, EC507742, EC507747, IC411825, EC507740
5	*GAI*	EC507744, EC507747, EC507739, IC411825, EC507741
6	*CV*	EC507744, EC507746, EC507748, EC507747, EC507740, EC507742
7	*Bi*	EC507744, EC507747, EC507746, EC507738, EC507740, EC507748
8	*Sdi*^{2}	EC507746, EC507748, EC507742, EC507747, IC411825, EC507740
9	*SI*	EC507744, EC507746, EC507748, IC411825, EC507738,
10	*Protein*	IC411825, EC507744, EC507740, EC507741
11.	$GSI_{(I)}$	IC411825, EC507748, EC507744, EC507747

promising lines had good combination of yield and stability. This indicated EC507748 is very important to get higher and stable yields in quinoa. The promising line EC507744 also gave higher average grain yield over locations but because of having less values of bi (0.49) and high S_{di}^2 (45.24) was not stable in its performance.

According to location variance S_{ti}^2, EC507744, EC507746, EC507748, EC507740 and EC507742 had lower variances across the locations and therefore were considered as stable in performance, whereas EC507743, EC507739, EC507741, IC411824 and EC507747 showed higher variances (Table 5) and thus were not stable in their performance. Similarly, promising lines EC507748, EC507746, EC507742 and IC411825 had lower *Wi*^{2} values and were stable in performance, whereas promising lines IC411824, EC507747, EC507741, EC507744 and EC507738 had higher *Wi*^{2} values and were unstable. According to coefficient variance parameters (*CV*), the promising lines EC507744, EC507746 and EC507748 were deemed stable due to their low values, whereas promising lines EC507741, EC507747, IC411824, EC507738 and EC507743 showed higher coefficient of variances and were deemed unstable.

As per *GAI* parameters, the promising lines EC507744, EC507747, EC507739, IC411825 and EC507741 were the best for yield stability, whereas the promising lines EC507743, EC507749 and EC507738 were poor in this respect (Table 5). Further, the promising lines EC507744, EC507746 and EC507748 also showed better sustainability as against the promising lines EC507747, EC507743, EC507739 and IC411824 which showed poor sustainability indices (Table 5).

The interrelationship among different statistical measures has been indicated in Table 6. The average grain yield was significantly and positively correlated with *GAI, PI, SI and Wi*^{2} (Category I), non-significantly and positively correlated with *Sti*^{2} (Category II) and negatively correlated with *CV, bi, Sdi2* (Category III). As the parameters under category I are most suitable to find out the best agronomical promising lines and therefore, either of these three (*GAI, PI, SI and Wi*^{2}) can suitably be used to find out best stable promising line. As per these parameters, the best stable promising line in the present case is EC507744, EC507746, EC507748, IC411825, EC507738 followed by EC507747, EC507739, EC507742. The promising line EC507741 gave high average yield but was unstable over the locations.

The inter-correlations of statistical parameters (Table 6) indicated that *St*^{2}, *GAI*, *CV* and *bi had* significant and positive correlations and thus, the stability of a promising line indicated by any one of the above indicated paired statistical parameters will be the same. This indicated that the information available from these statistical parameters like *St*^{2}, *GAI*, *CV* and *bi* will be most appropriate in finding out best quinoa promising line.

Combined stability index of promising line

A new approach known as a genotypic selection index was calculated by ranking the mean grain yield of the promising line across the location and standard deviation of the rank of eight stability measures. (Sdi), the rank of



Fig. 2: EC507744-most stable and highest potential yielding promising line.

standard deviation of the rank of eight stability measure were calculated. Genotypic Selection Index is measured in terms of sum of the rank yield, mean rank and the rank of standard deviation of rank stability measure (Raiger *et al.*, 2023). Low values of this parameter are considered for selection of the stable promising line and high yielding (Table 8). The advanced promising lines IC411825 ($CSI_{(I)}$=15), EC507748 ($CSI_{(I)}$=19), EC507744 ($CSI_{(I)}$=21), EC507747 ($CSI_{(I)}$=21) were identified as the most stable and high potential yielding promising line on the basis of index. Table 7 shows ranking frequencies for the stability measures and mean yield. The promising lines are divided in three layers (Top, Mid, Low) in each location. The promising line in the top five ranks from each location were categorized as the stable and adaptive. The stable promising line based on ranking frequency were EC507744 (7), EC507746 (7), EC507747 (8) and EC507748 (7).

The plots portrayed by mean grain yield (q/ha) and divided in to four sections. The promising lines EC507739, EC507744, EC507747, IC411825, having a high grain yield and small values of combine stability index can be considered as a stable and well adapted in all locations.

The genotypes EC507749, EC507747 and EC507743, which exhibit higher seed yield, can be incorporated into the breeding program to enhance quinoa seed yield (Manugade *et al.*, 2023). Quinoa's capacity to yield high-protein grains in ecologically harsh environments is crucial for the diversification of future agricultural practices, particularly in the elevated regions of the Himalayas and the North Indian Plains (Bhargava *et al.*, 2006). Gonzalez *et al.*, 2011 found that nutritional composition of quinoa cultivars is affected by both environmental and climatic factors in various agroecological regions.

The stability of this production is significantly important, particularly in the context of climate change uncertainty. Quinoa can thrive in various settings; however, Social-cultural factors continue to hold significance when contemplating its potential adoption as a primary food source in emerging agricultural systems globally (Bazile *et al.*, 2016). Maliro *et al.*, 2017 emphasized the importance of ongoing assessment of various cultivars to identify genotypes suited for particular agro-ecological zones and different seasons. The genotype × environment interaction accounting for 30% of the overall grain yield variation highlights the necessity of performing stability analysis and pinpointing stable genotypes (Jokarfard *et al.*, 2024).

Conclusion

This method of analysis is very useful for the selection of the high potential yielding promising lines for crop improvement programme. The eight stability measures used in this study quantified stability of varieties with respect to yield and stability. Simultaneous selection of promising lines for high yield and stability is useful for selection in refined manner. G × E interaction were highly significant ($p<0.05$), suggesting different response of promising lines to the test location/year. Based on low value of stability measures and combined stability index, IC411825 and EC507744 was identified most stable and highest potential yielding promising line.

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