

STUDIES ON VARIABILITY AND CHARACTER ASSOCIATION FOR YIELD AND ITS CONTRIBUTING TRAITS IN CHENOPODIUM GERMPLASM

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SUMMARY

In the present study a field experiment was conducted by using 40 genotypes of *Chenopodium quinoa* including checks at Research Farm of MAP Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar and experimental area of Department of Plant Breeding and Genetics, PAU, Ludhiana. In the present study, wide genetic variability was observed for all the characters studied. The seed yield at Hisar (E_1) varied from 10.3 to 312.0 g/plant. Out of 40 genotypes, the genotype EC896083 recorded the highest seed yield (312.0g/plant) followed by EC896202 (275.0), EC896115 (268.3), EC896097 (250.0) and EC896111 (241.7). However, in environment E_2 (Ludhiana) the seed yield varied from 10.3 to 312.0 g/plant. Out of 40 genotypes, the genotype EC896098 recorded the highest seed yield (290.0g/plant) followed by EC-507741 (266.7), EC896209 (265.0), SSQC-1 (258.3), EC896111 (225.0), EC896215 (225.0) and EC896115 (216.7). On average basis, it was observed that the genotypes, EC896115 recorded the highest seed yield (242.5g/plant) and EC896202 (242.5) followed by EC896111 (233.4), EC896209 (233.4), EC896083 (223.5), EC896097 (221.7) and EC896212 (200.0). The seed yield was significantly and positively correlated with leaf length (0.377), leaf width (0.424), petiole length (0.541) and number of inflorescence per plant (0.340). These genotypes have good potential for yield and its contributing traits, therefore, may be utilized in the breeding programme.

Key words: *Chenopodium*, genetic variability, seed yield, contributing traits

Potential crops are ancient plant species that have been used by local communities for ancient time and have been maintained by cultural preferences and traditional practices (Arya and Kumar, 2021). Globally, these crops have played an important role in strengthening the food security, nutrition, and income generation of the rural poor in several countries. (Magbagbeola *et al.*, 2010; Mayes *et al.*, 2011). These crops are more important than other commercially cultivated crops since they can be cultivated with low inputs and therefore provide economic and environmental benefits.

The genus *Chenopodium* (family: Amaranthaceae), have approximately 250 species including mostly facultative autogamous annuals distributed in temperate areas of the Americas, Asia and Europe (Jellen *et al.*, 2011). Out of these, only three, *C. quinoa* (2n=36), *C. pallidicaule* (2n=18) and *C. berlandieri* ssp. *nutalliae* (2n=36), have been cultivated as food crops (Zurita-Silva *et al.*, 2014).

However, the leaves and tender stems of several other species of the genus are used as food and fodder (Fuentes and Paredes-Gonzalez, 2015). Recently, chenopods have emerged as potential food crops for diversification in agriculture due to their nutritional superiority and adaptability to adverse climate so that the marginal lands and stressful climatic regions of the world to utilized for cultivation (Bazile *et al.*, 2016).

Quinoa (*Chenopodium quinoa* Willd.) has been cultivated since long as food plants in America. It has gained worldwide attention because of its ability to grow in various stress conditions like soil salinity, acidity, drought, frost, etc., (Jacobsen *et al.* 2003). Its grain is a rich source of a wide range of minerals, vitamins, oil and high quality protein containing ample amounts of sulphur rich amino acids (Behra *et al.*, 2025). These benefits forced the introduction of quinoa to new areas outside its native region, especially in the subtropical parts of the world. However, despite the immense potential of quinoa, significant efforts have

not been made for its genetic enhancement. (Mujica *et al.* 2001), but most of these are centered on three traits, namely, seed yield, biomass production and maturity period. Other yield contributing traits seem to have been overlooked which has resulted in absence of breeding plans to enhance yield and quality traits like seed protein and carotenoids.

MATERIALS AND METHODS

To conduct the field experiment, 40 genotypes of chenopodium including checks were grown in RBD during *rabi* 2018-19 at Research Farm of MAP Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar and at Research Farm of Pulses Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana. The plot size was kept 3.0 x 0.6 m² with spacing 30 x 10 cm². The soil of Hisar was found sandy loam (Typic Ustochrepts), tested medium in organic carbon (0.046%), available nitrogen (191kg/ha) and phosphorus (14kg/ha) and high in available potassium (340kg/ha). At PAU Ludhiana, soil type was loamy sand with pH7.7. It tested low in available nitrogen (156.4kg/ha), organic carbon (0.32%), medium in available potassium and phosphorous (198.7kg/ha and 16.5kg/ha, respectively). Each genotype was planted in paired rows of four meter length spacing 30cm apart. All the recommended package of practices was carried out to raise a good crop. Data were recorded on five randomly selected plants for days to 50% flowering, leaf length (cm), leaf width (cm), number of leaves, number of internodes, petiole length (cm), number of primary branches, number of inflorescence per plant, length of inflorescence (cm), plant height (cm), days to 80% maturity and seed yield per plant (g). The data were subjected statistical analysis as per standard procedure.

RESULTS AND DISCUSSION

The results of Hisar location (E₁) presented in table 1 revealed that the days to 50% flowering was varied from 80.7 to 105.7 days with average plant height 91.37 days. The genotypes, EC896203 (80.87 days), EC896111 (81.33 days), EC896114 (85.33 days) and EC896210 (85.33 days) were found early in days to 50% flowering. Likewise, at Ludhiana (E₂), the days to 50% flowering was varied from 79.3 to 107.0 cm with average plant height 90.7 days. The genotypes, EC896203 (79.3 days), EC896111 (82.0

days), and EC896210 (84.7 days) were found early in days to 50% flowering. On average basis, it was observed that the genotypes, EC896203 (80.0 days), EC896111 (81.7 days), and EC896210 (85.0 days) were found early in days to 50% flowering.

In environment E₁, the Leaf length (cm) ranged from 3.5 to 7.3cm with an average 4.9cm. Leaf length (cm) was observed maximum in genotype EC896111 (7.3cm) followed by EC896083 (7.2cm) and EC896206 (6.3cm). However, in environment E₂, the Leaf length (cm) ranged from 4.5 to 8.1cm with an average 6.2cm. Leaf length (cm) was observed maximum in genotype EC-507738 (C) (8.1cm) followed by EC896115 (7.9cm) and EC-507741 (C) (7.9cm). On average basis, it was observed that the genotypes, Leaf length (cm) was observed maximum in genotype EC-507738 (C) (7.9cm) and EC896115 (7.9cm) followed by EC896083 (7.5cm). Likewise, in environment E₁ leaf width (cm) ranged from 2.3 to 4.8cm with an average 3.1cm and it was found maximum in genotype EC896083 (4.8cm) followed by EC896115 (4.5cm), EC896111 (4.4cm) and EC896210 (4.4cm). However, in environment E₂, leaf width (cm) ranged from 2.6 to 6.7cm with an average 4.3cm and it was found maximum in genotype EC507738 (6.7cm) followed by EC896115 (6.4cm), EC896212 (5.8cm), EC-507741 (5.7cm) and EC896109 (5.7cm). On average basis, it was observed that the genotypes, leaf width (cm) was maximum in genotype EC896115 (5.5cm) followed by EC-507738 (C) (5.1cm), EC896083 (5.0cm), and EC-507741 (4.5cm).

In environment E₂, the average number of leaves was recorded 144.1, but, it ranged from 87.0 to 201.3. Number of leaves were found maximum in EC896206 (201.3), EC896111 (193.7), EC896090 (185.0), EC896115 (183.3) and EC896215 (177.3). However, in environment E₂, the average number of leaves ranged from 81.7 to 173.3 with an average 135.2 and it was found maximum in genotype EC896111 (173.3) followed by EC896098 (171.7), EC896097 (163.3), EC896083 (163.3) and EC896115 (163.3). On average basis, it was observed that the genotypes, the average number of leaves were maximum in genotype EC896111 (183.5) followed by EC896212 (180.5), EC896115 (173.3), EC896098 (167.9), and EC896097 (160.0).

The numbers of internodes were varied from 19.7 to 87.7 with average plant height 30.5. Out of 42 genotypes, the genotype EC896090 (41.7) was highest in number of internodes and followed by EC896110

TABLE 1
Performance of germplasm of *Chenopodium quinoa* during at Hisar and Ludhiana

S. No.	Accessions No.	Days to 50% flowering			Leaf length (cm)			Leaf width (cm)			Number of leaves			Number of internodes			Petiole length (cm)		
		E ₁	E ₂	Mean	E ₁	E ₂	Mean	E ₁	E ₂	Mean	E ₁	E ₂	Mean	E ₁	E ₂	Mean	E ₁	E ₂	Mean
1.	EC896059	101.7	98.7	100.2	4.7	5.0	4.9	2.5	2.6	2.6	87.0	81.7	84.4	28.7	27.3	28.0	2.0	2.1	2.1
2.	EC896067	99.3	97.3	98.3	5.7	6.0	5.9	2.9	3.2	3.1	130.7	140.0	135.4	23.7	26.7	25.2	2.3	2.4	2.4
3.	EC896083	87.3	85.7	86.5	7.2	7.7	7.5	4.8	5.1	5.0	153.0	163.3	158.2	19.7	19.3	19.5	4.2	2.8	3.5
4.	EC896086	89.0	88.7	88.9	5.2	5.3	5.3	3.6	3.8	3.7	130.0	129.3	129.7	32.0	16.3	24.2	4.2	4.1	4.2
5.	EC896087	90.3	88.3	89.3	4.0	5.0	4.5	2.9	3.8	3.4	123.0	136.0	129.5	27.3	15.3	21.3	5.2	2.8	4.0
6.	EC896088	94.3	91.3	92.8	4.8	6.1	5.5	3.0	4.2	3.6	129.3	160.3	144.8	24.3	20.0	22.2	3.2	3.9	3.6
7.	EC896089	88.3	86.3	87.3	4.1	5.3	4.7	2.8	3.3	3.1	133.3	137.3	135.3	36.7	15.7	26.2	2.9	2.8	2.9
8.	EC896090	90.7	87.7	89.2	5.4	6.6	6.0	3.7	4.2	4.0	185.0	126.0	155.5	41.7	26.3	34.0	3.0	3.5	3.3
9.	EC896091	105.7	107.0	106.4	3.8	5.1	4.5	2.7	3.1	2.9	135.0	147.7	141.4	23.0	18.7	20.9	2.7	3.9	3.3
10.	EC896097	90.0	88.0	89.0	5.1	7.1	6.1	3.9	4.8	4.4	156.7	163.3	160.0	26.3	18.3	22.3	4.0	3.6	3.8
11.	EC896098	93.7	94.3	94.0	5.3	6.1	5.7	3.8	4.7	4.3	164.0	171.7	167.9	25.7	20.3	23.0	2.8	2.6	2.7
12.	EC896100	89.7	87.0	88.4	4.0	4.5	4.3	2.7	3.6	3.2	122.0	114.3	118.2	27.0	11.0	19.0	3.8	3.1	3.5
13.	EC896105	92.0	91.7	91.9	4.2	5.8	5.0	3.0	3.5	3.3	140.7	131.7	136.2	36.3	27.7	32.0	3.6	4.0	3.8
14.	EC896108	91.3	90.7	91.0	4.4	6.0	5.2	3.0	3.5	3.3	138.7	146.7	142.7	32.3	21.0	26.7	2.9	4.7	3.8
15.	EC896109	89.7	88.3	89.0	4.3	6.7	5.5	3.1	5.7	4.4	137.0	142.0	139.5	27.3	18.0	22.7	3.0	3.4	3.2
16.	EC896110	89.3	88.7	89.0	4.8	5.7	5.3	3.2	4.7	4.0	161.7	91.7	126.7	40.0	24.7	32.4	3.5	3.2	3.4
17.	EC896111	81.3	82.0	81.7	7.3	5.4	6.4	4.4	3.9	4.2	193.7	173.3	183.5	37.0	21.7	29.4	6.1	2.6	4.4
18.	EC896112	88.3	87.7	88.0	3.5	6.0	4.8	3.1	3.6	3.4	137.3	161.7	149.5	27.7	13.3	20.5	2.9	3.3	3.1
19.	EC896114	85.3	86.7	86.0	5.8	6.5	6.2	3.6	4.3	4.0	149.0	148.3	148.7	32.7	17.3	25.0	4.4	3.4	3.9
20.	EC896115	99.0	96.7	97.9	5.9	7.9	6.9	4.5	6.4	5.5	183.3	163.3	173.3	35.0	32.0	33.5	4.5	3.0	3.8
21.	EC896116	102.0	102.7	102.4	3.5	5.0	4.3	2.7	4.4	3.6	140.3	135.0	137.7	30.0	20.7	25.4	2.5	3.6	3.1
22.	EC896202	88.3	87.3	87.8	5.0	6.1	5.6	2.8	3.5	3.2	158.0	150.7	154.4	30.7	15.3	23.0	3.0	3.5	3.3
23.	EC896203	80.7	79.3	80.0	4.7	7.3	6.0	2.7	5.0	3.9	139.3	113.3	126.3	33.0	17.0	25.0	3.0	3.9	3.5
24.	EC896205	87.3	88.3	87.8	4.2	6.0	5.1	2.7	4.0	3.4	121.0	119.0	120.0	21.0	26.0	23.5	2.4	2.4	2.4
25.	EC896206	95.0	94.7	94.9	6.3	6.7	6.5	3.0	5.1	4.1	201.3	116.3	158.8	31.3	27.0	29.2	3.1	2.5	2.8
26.	EC896207	87.0	86.3	86.7	5.4	4.7	5.1	3.2	3.0	3.1	165.3	119.0	142.2	32.7	12.7	22.7	2.9	3.5	3.2
27.	EC896208	93.7	94.3	94.0	4.6	7.0	5.8	2.8	4.5	3.7	142.3	104.0	123.2	31.0	28.3	29.7	3.5	3.2	3.4
28.	EC896209	90.0	88.0	89.0	4.5	4.9	4.7	2.8	3.2	3.0	140.3	158.3	149.3	30.7	19.7	25.2	4.7	4.1	4.4
29.	EC896210	85.3	84.7	85.0	5.3	6.0	5.7	4.4	4.3	4.4	150.7	131.0	140.9	24.3	20.7	22.5	3.5	3.2	3.4
30.	EC896212	85.7	87.7	86.7	5.7	7.4	6.6	2.7	5.8	4.3	223.3	137.7	180.5	32.3	17.7	25.0	3.0	2.7	2.9
31.	EC896215	89.0	88.7	88.9	5.2	5.6	5.4	2.5	3.6	3.1	177.3	144.0	160.7	28.0	19.7	23.9	3.1	3.1	3.1
32.	EC896233	89.0	88.3	88.7	3.9	5.4	4.7	2.9	4.1	3.5	144.0	101.7	122.9	25.3	14.7	20.0	2.6	2.2	2.4
33.	EC896237	87.0	86.7	86.9	4.7	6.4	5.6	3.5	4.9	4.2	159.3	107.7	133.5	25.3	21.0	23.2	2.8	2.5	2.7
34.	EC896246	89.3	88.3	88.8	4.0	6.0	5.0	2.5	3.8	3.2	103.7	117.7	110.7	22.7	24.3	23.5	3.3	3.0	3.2
35.	EC896264	102.0	103.3	102.7	5.1	5.8	5.5	2.8	3.7	3.3	130.7	101.7	116.2	25.7	22.7	24.2	4.0	2.8	3.4
36.	EC896271	90.0	89.0	89.5	4.8	6.7	5.8	2.5	4.2	3.4	125.3	133.3	129.3	25.0	21.7	23.4	3.8	3.6	3.7
37.	EC896275	89.0	88.0	88.5	5.0	7.2	6.1	2.3	4.8	3.6	134.3	140.0	137.2	27.7	20.3	24.0	5.3	3.5	4.4
38.	EC-507741 (C)	98.0	98.3	98.2	5.1	7.9	6.5	3.2	5.7	4.5	147.7	163.3	155.5	27.7	16.3	22.0	3.7	3.3	3.5
39.	EC-507738 (C)	102.0	100.7	101.4	5.6	8.1	6.9	3.5	6.7	5.1	130.7	130.7	130.7	33.0	20.0	26.5	2.8	3.2	3.0
40.	SSQC-1 (C)	92.0	90.3	91.2	5.3	5.6	5.5	2.9	4.8	3.9	144.7	154.0	149.4	32.0	21.7	26.9	3.1	3.5	3.3
	Mean	91.4	90.7	91.1	4.9	6.2	5.5	3.1	4.3	3.7	146.7	135.2	141.0	29.3	20.5	24.9	3.4	3.2	3.3
	Range	80.6-105.6	79.3-107.0	81.0-107.0	3.5-7.3	4.5-8.1	4.5-8.1	2.3-4.8	2.6-6.7	2.6-6.7	87.0-223.3	81.7-173.3	135.2-180.5	19.6-34.3	11.0-34.3	11.0-34.3	2.0-6.1	2.0-4.7	2.0-4.7

contd...

Table 1 contd.

S. No.	Accessions No.	Number of primary branches			Number of inflorescence/ plant			Length of inflorescence (cm)			Plant height (cm)			Days to 80% maturity			Seed yield per plant (g)		
		E ₁	E ₂	Mean	E ₁	E ₂	Mean	E ₁	E ₂	Mean	E ₁	E ₂	Mean	E ₁	E ₂	Mean	E ₁	E ₂	Mean
1.	EC896059	27.3	26.7	27.0	16.3	16.7	16.5	13.3	14.7	14.0	137.3	150.3	143.8	151.7	179.7	165.7	10.3	9.3	9.8
2.	EC896067	27.0	24.7	25.9	23.7	26.7	25.2	15.3	17.0	16.2	86.3	82.0	84.2	162.0	157.0	159.5	20.7	21.7	21.2
3.	EC896083	27.7	17.7	22.7	18.0	33.3	25.7	13.7	26.3	20.0	95.7	94.7	95.2	153.0	154.7	153.9	312.0	135.0	223.5
4.	EC896086	32.0	15.3	23.7	22.0	23.7	22.9	15.3	21.3	18.3	100.0	81.7	90.9	151.3	153.3	152.3	158.3	75.0	116.7
5.	EC896087	33.0	12.3	22.7	23.3	27.3	25.3	11.0	18.7	14.9	96.3	92.3	94.3	150.3	153.0	151.7	212.0	103.3	157.7
6.	EC896088	23.0	15.7	19.4	30.3	37.3	33.8	17.3	24.7	21.0	99.7	92.7	96.2	147.3	150.7	149.0	201.7	206.7	204.2
7.	EC896089	31.0	14.0	22.5	29.0	34.3	31.7	12.7	21.0	16.9	96.0	91.0	93.5	149.3	148.7	149.0	196.7	136.7	166.7
8.	EC896090	39.0	23.0	31.0	31.3	21.3	26.3	17.7	26.3	22.0	119.3	95.7	107.5	151.0	153.0	152.0	160.0	93.3	126.7
9.	EC896091	22.0	16.7	19.4	25.3	31.3	28.3	15.0	20.7	17.9	100.3	94.7	97.5	145.0	145.7	145.4	175.0	165.0	170.0
10.	EC896097	24.0	17.0	20.5	28.7	34.7	31.7	11.3	25.3	18.3	120.7	101.3	111.0	139.7	157.3	148.5	250.0	193.3	221.7
11.	EC896098	19.3	19.0	19.2	35.0	41.7	38.4	19.7	27.0	23.4	100.0	107.7	103.9	155.7	159.3	157.5	106.7	290.0	198.4
12.	EC896100	23.0	10.0	16.5	16.0	17.3	16.7	14.0	22.3	18.2	113.0	85.3	99.2	150.0	156.0	153.0	80.3	66.7	73.5
13.	EC896105	34.0	25.7	29.9	24.3	18.7	21.5	17.0	25.0	21.0	119.0	107.3	113.2	161.3	160.7	161.0	95.7	96.7	96.2
14.	EC896108	28.7	19.3	24.0	28.0	26.7	27.4	17.7	27.3	22.5	141.0	108.7	124.9	149.3	150.7	150.0	100.3	133.3	116.8
15.	EC896109	16.0	17.3	16.7	15.0	22.7	18.9	16.7	24.0	20.4	91.3	104.7	98.0	159.3	160.0	159.7	71.7	88.3	80.0
16.	EC896110	36.3	21.0	28.7	27.0	10.7	18.9	12.3	20.3	16.3	134.0	102.0	118.0	176.3	181.0	178.7	148.3	33.3	90.8
17.	EC896111	28.7	18.0	23.4	32.0	35.3	33.7	20.0	26.0	23.0	137.7	89.0	113.4	153.0	152.7	152.9	241.7	225.0	233.4
18.	EC896112	20.3	13.0	16.7	17.3	31.3	24.3	13.3	20.3	16.8	105.0	93.3	99.2	151.7	154.7	153.2	109.3	215.0	162.2
19.	EC896114	20.7	16.7	18.7	18.7	29.7	24.2	14.7	24.0	19.4	104.7	98.7	101.7	155.3	154.0	154.7	193.3	166.7	180.0
20.	EC896115	41.7	30.7	36.2	26.7	33.3	30.0	14.7	25.3	20.0	171.7	128.7	150.2	162.3	160.7	161.5	268.3	216.7	242.5
21.	EC896116	28.3	20.3	24.3	25.0	23.7	24.4	15.3	23.0	19.2	102.0	106.7	104.4	157.7	158.7	158.2	92.3	116.0	104.5
22.	EC896202	15.9	13.7	14.8	22.7	34.7	28.7	16.3	23.3	19.8	108.3	81.3	94.8	155.0	154.7	154.9	275.0	210.0	242.5
23.	EC896203	26.3	16.7	21.5	21.0	15.3	18.2	15.3	21.3	18.3	96.0	73.0	84.5	144.0	145.3	144.7	80.0	75.0	77.5
24.	EC896205	26.0	24.0	25.0	19.0	14.3	16.7	13.3	23.0	18.2	127.0	129.7	128.4	161.0	159.3	160.2	80.0	75.0	77.5
25.	EC896206	30.7	24.3	27.5	22.7	10.7	16.7	17.7	29.3	23.5	127.0	97.0	112.0	162.0	161.3	161.7	61.7	65.0	63.4
26.	EC896207	24.7	12.3	18.5	15.0	11.0	13.0	13.7	21.0	17.4	100.7	88.3	94.5	147.3	145.3	146.3	131.7	55.0	93.4
27.	EC896208	25.0	25.3	25.2	22.0	11.7	16.9	11.0	23.7	17.4	103.3	97.3	100.3	159.3	160.0	159.7	146.7	41.7	94.2
28.	EC896209	19.0	15.7	17.4	19.0	37.0	28.0	17.3	27.7	22.5	88.0	85.0	86.5	147.0	146.7	146.9	201.7	265.0	233.4
29.	EC896210	18.0	18.0	18.0	15.7	26.7	21.2	15.7	31.7	23.7	89.3	112.3	100.8	166.0	153.7	159.9	122.3	168.3	145.3
30.	EC896212	26.3	14.3	20.3	22.0	30.0	26.0	21.0	24.0	22.5	137.0	139.0	138.0	159.7	156.0	157.9	193.3	208.3	200.8
31.	EC896215	20.3	16.3	18.3	20.7	33.7	27.2	12.7	23.3	18.0	122.0	105.7	113.9	156.3	155.0	155.7	169.0	225.0	197.0
32.	EC896233	32.0	12.0	22.0	22.3	9.0	15.7	18.0	23.3	20.7	96.0	68.3	82.2	157.0	158.7	157.9	25.7	28.3	27.0
33.	EC896237	26.3	20.3	23.3	18.7	11.0	14.9	15.0	25.3	20.2	78.3	93.0	85.7	155.0	155.3	155.2	35.0	40.0	37.5
34.	EC896246	18.3	21.0	19.7	13.7	16.0	14.9	18.0	22.7	20.4	76.7	77.3	77.0	188.0	180.0	184.0	45.7	61.7	53.7
35.	EC896264	25.3	23.3	24.3	16.3	9.7	13.0	16.7	29.0	22.9	92.0	95.7	93.9	163.0	164.7	163.9	30.0	26.7	28.4
36.	EC896271	16.0	20.0	18.0	15.0	28.7	21.9	16.0	21.0	18.5	85.0	89.7	87.4	150.3	151.7	151.0	120.0	191.7	155.9
37.	EC896275	23.3	19.7	21.5	21.7	26.3	24.0	17.0	25.7	21.4	84.7	92.7	88.7	151.0	153.7	152.4	108.3	155.0	131.7
38.	EC-507741 (C)	31.0	15.7	23.4	31.0	38.7	34.9	19.0	25.3	22.2	123.7	140.3	132.0	157.0	158.0	157.5	120.0	266.7	193.4
39.	EC-507738 (C)	36.3	17.7	27.0	25.0	14.0	19.5	19.7	33.0	26.4	118.7	139.7	129.2	168.0	167.7	167.9	31.7	38.3	35.0
40.	SSQC-1 (C)	28.3	21.3	24.8	29.0	35.7	32.4	17.0	23.0	20.0	100.7	104.0	102.4	155.0	154.3	154.7	133.3	258.3	195.8
	Mean	26.3	18.6	22.5	22.6	24.8	23.7	15.7	23.9	19.8	108.1	100.4	104.3	159.7	157.1	156.5	132.9	131.1	132.0
	Range	15.9-	10.0-		13.7-	9.0-		11.0-	14.7-		76.7-	68.3-		139.7-	145.3-		10.3-	9.3-	
		41.6	30.7		35.0	41.7		21.0	33.0		171.7	150.7		188.0	187.0		312.0	290.0	

E₁= CCS HAU HISAR, E₂= PAU Ludiana.

(40.0), EC896089 (36.7) and EC896105 (36.3). However, in environment E_2 , the average number of internodes ranged from 11.0 to 32.0 with an average 20.5 and it was found maximum in genotype EC896115 (32.0), followed by EC896208 (28.3), EC896105 (27.7), EC896059 (27.3) and EC896206 (27.0). On average basis, it was observed that the genotypes, the average number of internodes were maximum in genotype EC896090 (34.0), followed by EC896115 (33.5), EC896110 (32.4), EC896105 (32.0), and EC896208 (29.7).

The petiole length was varied from 2.0 to 6.1cm with average plant height 3.4cm. Out of 42 genotypes, the genotype EC896111 (6.1) was longest in petiole length followed by EC896275 (5.3), EC896087 (5.2), EC896115 (4.5) and EC896114 (4.4). However, in environment E_2 , petiole length (cm) ranged from 2.1 to 4.7cm with an average 3.2cm and it was found maximum in genotype EC896108 (4.7cm) followed by EC896086 (4.1cm), EC896209 (4.1cm), EC896088 (3.9cm) and EC896091 (3.9cm). On average basis, it was observed that the genotypes, petiole length (cm) was maximum in genotypes EC896111 (4.4cm), EC896209 (4.4cm) and EC896275 (4.4cm) followed by EC896086 (4.2cm), and EC896087 (4.0cm).

The number of primary branches/plant ranged from 15.9 to 41.6 with an average 26.3. The genotype EC896115 (41.6) was having maximum number of primary branches/plant 6.0 and followed by EC896090 (39.0), EC896110 (36.3), EC-507738 (36.3). However, in environment E_2 , the average number of primary branches/plant ranged from 10.0 to 30.7 with an average 18.6 and it was found maximum in genotype EC896115 (30.7) followed by EC896059 (26.7), EC896105 (25.7), EC896208 (25.3) and EC896067 (24.7). On average basis, it was observed that the genotypes, the average number of primary branches/plant were maximum in genotype EC896115 (36.2) followed by EC896090 (31.0), EC896115 (29.9), EC896110 (28.7) and EC896206 (27.5).

The number of inflorescence per plant ranged from 13.7 to 35.0 with an average 22.6. The genotype EC896098 was having maximum number of inflorescence per plant 35.0 and followed by EC896111 (32.0), EC896090 (31.3), EC-507741 (31.0), and EC896088 (30.3). However, in environment E_2 , the average number of inflorescence per plant ranged from 9.0 to 41.7 with an average 24.8 and it was found maximum in genotype EC896098 (41.7) followed by EC507741 (38.7), EC896088 (37.3), EC896209

(37.0), SSQC-1 (35.7) and EC896111 (35.3). On average basis, it was observed that the genotypes, the average number of inflorescence per plant were maximum in genotype EC896098 (38.4) followed by EC507741 (34.9), EC896088 (33.8), EC896111 (33.7), SSQC-1 (32.4) and

The average length of inflorescence (cm) was recorded 15.7cm, but, it ranged from 11.0 to 21.0cm. The genotype EC896212 was having the longest inflorescence (21.0cm) followed by EC896111 (20.0), EC-507738 (19.7), EC896098 (19.7) and EC-507741 (19.0). However, in environment E_2 , length of inflorescence (cm) ranged from 14.7 to 33.0cm with an average 23.9cm and it was found maximum in genotype EC507738 (33.0cm) followed by EC896210 (31.7cm), EC896206 (29.3cm), EC896264 (29.0cm), and EC896209 (27.7cm). On average basis, it was observed that the genotypes, length of inflorescence (cm) was maximum in genotype EC507738 (26.4cm) followed by EC896210 (23.7cm), EC896206 (23.5cm), EC896098 (23.4cm) and EC896111 (23.0cm).

The plant height was varied from 76.7 to 171.7cm with average plant height 108.1cm. The genotype EC896115 (171.7cm), was tallest followed by EC896108 (141.0cm), EC896111 (137.7cm), EC896212 (137.0cm) and EC896110 (134.0cm). However, in environment E_2 plant height (cm) ranged from 68.3 to 150.3cm with an average 100.4cm and it was found maximum in genotype EC896115 (150.3cm) followed by EC-507741 (140.3), EC-507738 (139.7cm), EC896212 (139.0cm), and EC896205 (129.7cm). On average basis, it was observed that the genotypes, plant height (cm) was maximum in genotype EC896059 (143.8cm), EC896212 (138.0cm), EC-507741 (132.0cm) and EC-507738 (129.2cm).

The days to 80% maturity ranges from 139.7 to 188.0days with the average 155.9days. The genotype, EC896097 (139.7) was earliest in maturity followed by EC896209 (147.0), EC896229 (147.0), EC896088 (147.3) and EC896207 (147.3). Likewise, at Ludhiana (E_2), the days to 80% maturity was varied from 145.3 to 187.0 days with average plant height 157.1 days. The genotypes, EC896203 (145.3 days), EC896207 (145.3 days), EC896091 (145.7 days), and EC896209 (146.7 days) were found early in days to 80% maturity. On average basis, it was observed that the genotypes, EC896203 (144.7 days), EC896091 (145.4 days), EC896207 (146.3 days) and EC896209 (146.9 days) were found early in days to 80% maturity.

In environment E₁, the seed yield varied from 10.3 to 312.0 g/plant. Out of 40 genotypes, the genotype EC896083 recorded the highest seed yield (312.0g/plant) followed by EC896202 (275.0), EC896115 (268.3), EC896097 (250.0) and EC896111 (241.7). However, in environment E₂ the seed yield varied from 10.3 to 312.0 g/plant. Out of 40 genotypes, the genotype EC896098 recorded the highest seed yield (290.0g/plant) followed by EC-507741 (266.7), EC896209 (265.0), SSQC-1 (258.3), EC896111 (225.0), EC896215 (225.0) and EC896115 (216.7). On average basis, it was observed that the genotypes, EC896115 recorded the highest seed yield (242.5g/plant) and EC896202 (242.5) followed by EC896111 (233.4), EC896209 (233.4), EC896083 (223.5), EC896097 (221.7) and EC896212 (200.0). The extensive genetic variability observed in traits underscores quinoa's potential for breeding improvement (Behra *et al.*, 2025).

The seed yield was significantly and positively correlated with leaf length (0.377), leaf width (0.424), petiole length (0.541) and number of inflorescence per plant (0.340). These genotypes have good potential for yield and its contributing traits, Therefore, may be utilized in the breeding programme for the development of potential yielding varieties for commercial cultivation. Above results are consistent with the outcomes of Bazile *et al.* (2016) and (Behra *et al.*, 2025), they stressed the significance of these characters to increase seed yield through breeding strategies. The significant positive associations among the seed yield and its attributes advocate that simultaneous selection for these characters can lead to improvement in seed yield.

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