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Metroglyph Analysis of Morphological Variation in *Chenopodium* spp.

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Abstract: Metroglyph analysis was carried out among 44 indigenous and exotic germplasm lines of *Chenopodium* spp. for 10 quantitative characters. The germplasm lines could be categorized into 10 groups, which differed amongst themselves. Group 1 was the largest comprising 22 lines having tall plants with thick stem, large leaf area, long inflorescence and greater maturity period. All indigenous hexaploid *C. album* types except C 13 were vigorous and showed high grain yield, while the indigenous diploid *C. album* types had medium to high grain yield. An interesting feature of the metroglyph was the distribution of *C. album* and *C. quinoa* in different clusters. A breeding plan to evolve high yielding varieties is discussed.

Key words: *Chenopodium* · Medicinal uses · Morphological variation · Metroglyph · Index score

INTRODUCTION

Chenopodiaceae is one of the largest dicotyledonous family which contains mainly halophytic herbs, rarely shrubs or trees [1]. *Chenopodium* is the principal genus of this family and comprises about 120 species. *C. quinoa*, *C. pallidicaule*, *C. album* and *C. berlandieri* are cultivated as grain crop in various parts of the world [2-5]. Chenopod leaves are rich in carotenoids (78-190 mg/kg), their seeds protein (106-142 g/kg) and fat contents (30-62 g/kg) [6]. Moreover, the seed proteins have a balanced amino acid spectrum with high lysine (5.1-6.4%) and methionine (0.4-1.0 %) contents [7]. *Chenopodium* has a high level of resistance to adverse conditions like drought, frost and soil salinity [8-11]. The crop provides great scope for supplementing the protein deficient food for poor people in developing countries.

Many species of *Chenopodium* have been reported to possess numerous medicinal properties in ancient texts like Ayurveda, Atharva Veda, Charak Samhita, Sushruta Samhita etc. [12]. Modern pharmaceutical studies have also confirmed that the plant has potent antipruritic and antinociceptive [13], anthelmintic [14], antiparasitic [15], antispasmodic [16], antibacterial and antifungal [17,18] properties. Seeing the immense medicinal potential of *Chenopodium* spp., there is an urgent need for genetic improvement in the crop. The knowledge of genetic variation existing in the germplasm is an important and essential aspect for initiatiating any crop breeding programme. Metroglyph analysis and index scoring have been used as useful tools for studying the morphological variations in a number of crops [19,20]. Till date no study on metroglyph analysis in *Chenopodium* has been performed, so, the present study was conducted to study the variations in different morphological characters of *Chenopodium* spp.

MATERIALS AND METHODS

In the present investigation, 44 distinct germplasm lines of *Chenopodium* spp. (Table 1) were sown in a randomized block design in 3 replications during 2000-2001 at the experimental plot in National Botanical Research Institute, Lucknow. The experimental site is situated at an altitude of 120 m above sea level at 26.5°N latitude and 80.5°E longitude. Each genotype was sown in 2 rows of 3 m long. The row-to-row distance was maintained at 45 cm and plant-to-plant distance at 15 cm. The data was recorded on 5 plants from each replication for 10 traits namely days to flowering, days to maturity, plant height (cm), leaf area (cm^2), stem diameter (cm), number of primary branches/plant, inflorescence length (cm), 100 seed weight (g), number of inflorescence/plant and seed yield/plant (g).

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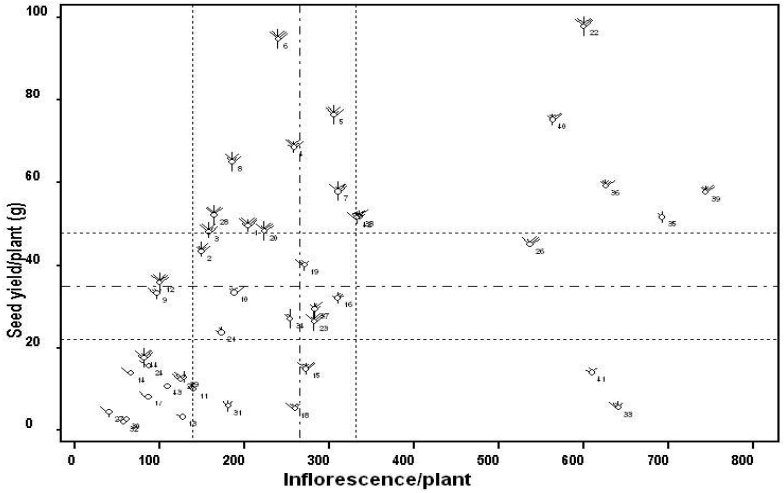

Fig. 1: Scatter diagram of metroglyphs representing different germplasm lines of *Chenopodium* spp

Table 1: Germplasm lines, their source, chromosome number and ploidy levels

S. No.	Germplasm line	Origin	Chromosome number	Ploidy level
CA 1	*C. album* PRC 9801	H.P., India	54	6x
CA 2	*C. album* PRC 9803	H.P., India	54	6x
CA 3	*C. album* PRC 9804	H.P., India	54	6x
CA 4	*C. album* PRC 9802	H.P., India	54	6x
CA 5	*C. album* IC 107295	H.P., India	54	6x
CA 6	*C. album* IC 107297	H.P., India	54	6x
CA 7	*C. album* IC 107299	H.P., India	54	6x
CA 8	*C. album* IC 107296	H.P., India	54	6x
CA 9	*C. quinoa* PI 587173	Jujuy, Argentina*	36	4x
CA 10	*C. album* 'local red'	Lucknow, India	18	2x
CA 11	*C. bushianum* Ames 22376	Illinois, USA*	36	4x
CA 12	*C. album* 'Iowa'	Iowa, USA	54	6x
CA 13	*C. album* 'H.P'	H.P., India	54	6x
CA 14	*C. quinoa* PI 510537	Peru*	36	4x
CA 15	*C. quinoa* CHEN 92/91	Columbia**	36	4x
CA 16	Progenitor of quinoa	Mexico	36	4x
CA 17	*C. quinoa* PI 478414	La Paz, Bolivia*	36	4x
CA 18	*C. album* (local) x *C. quinoa*	Hybrid	54	6x
CA 19	*C. quinoa* PI 584524	Chile*	36	4x
CA 20	*C. giganteum* 'local'	Lucknow, India	54	6x
CA 21	*C. album* 'Mexico'	Mexico	36	4x
CA 22	*C. album* x *C. album* 'Siliguri'	Hybrid	18	2x
CA 23	*C. album* 'Siliguri'	Siliguri, India	18	2x
CA 24	*C. quinoa* PI 596498	Cuzco, Peru*	36	4x
CA 25	*C. quinoa* Ames 22158	Chile*	36	4x
CA 26	*C. album* 'chandanbathua'	U.P., India	18	2x
CA 27	*C. quinoa* CHEN 67/78	Puno, Peru**	36	4x
CA 28	*C. album* 'amaranticolor'	H.P., India	54	6x
CA 29	*C. quinoa* CHEN 71/78	Bolivia**	36	4x
CA 30	*C. album* CHEN 60/76	Belgium**	54	6x
CA 31	*C. album* CHEN 85/82	Unknown**	54	6x
CA 32	*C. album* 'Czech'	Czech Republic	54	6x
CA 33	*C. album* x *C. quinoa* (colchiploid)	Hybrid	54	6x
CA 34	*C. murale* 'local'	Lucknow, India	18	2x
CA 35	*C. opulifolium* CHEN 43/96	Unknown**	36	4x
CA 36	*C. album* PI 605700	Michigan, USA*	54	6x
CA 37	*C. album* 'local 6x'	Lucknow, India	54	6x
CA 38	*C. giganteum* PI 596371	Oklahoma, USA*	54	6x
CA 39	*C. giganteum* PI 596372	California, USA*	54	6x
CA 40	*C. album* 'local'	Lucknow, India	18	2x
CA 41	*C. strictum* CHEN 47/79	Unknown**	54	6x
CA 42	*C. berlandieri* PI 568156	Mexico*	36	4x
CA 43	*C. album* CHEN 63/80	Unknown**	54	6x
CA 44	*C. ugandae* CHEN 77/78	Rwanda**	36	4x

*Source- USDA

**Source- Gatersleben,Germany

Table 2: Class intervals for 8 quantitative characters in *Chenopodium*

Character	Less than		From	To		Greater than	
Days to flowering	100.378	♀	100.378	109.551	♀	118.725	♀
Days to maturity	131.521	♂	131.521	143.012	♂	154.502	♂
Plant height (cm)	104.824	♂	104.824	150.536	♂	196.248	♂
Leaf size (cm*cm)	12.025	♂	12.025	29.478	♂	46.931	♂
Stem diameter (cm)	1.116	♂	1.116	1.373	♂	1.630	♂
Primary cranches/pla	22.265	♂	22.265	28.330	♂	34.395	♂
Inflorescence lenght	12.148	♂	12.148	17.980	♂	23.812	♂
100 seed weight (g)	0.063	♂	0.063	0.102	♂	0.141	♂

The data was subjected to metroglyph analysis using the index score method of Anderson [21]. A scatter diagram was plotted taking two most variable characters, viz., grain yield as ordinate and number of inflorescence/plant as abscissa (Fig. 1). Eight other morphological characters are represented as rays at different positions on the glyph. Each germplasm line bears a serial number and is represented as a glyph which is the intersection point of mean values of X and Y co-ordinates. The sum of index values with regard to all the characters allotted to an individual is the indication of the individual worth. The index values and the position of rays and arrows for the different characters are given in Table 2.

RESULTS AND DISCUSSION

The scatter diagram drawn on the basis of different morphological characters showed that the germplasm lines having common characters with high index values fell into one big group, four smaller ones and five others with only a single germplasm line (Table 3). For convenience, the groups have been numbered in the scatter diagram. Accordingly, Group I was the largest comprising 22 lines (Table 3) having tall plants with thick

Table 3: Germplasm lines of *Chenopodium* spp. falling in different groups

Grouping	No. of Germplasm lines	Germplasm line serial numbers (as per Table 1)
I	22	C 1, C 2, C 3, C 4, C 5, C 6, C 7, C 8, C 9, C 12, C 15, C 16, C 19, C 20, C 22, C 23, C 28, C 37, C 38, C 40, C 42, C 44
II	9	C 11, C 13, C 14, C 17, C 24, C 27, C 30, C 32, C 43
III	3	C 21, C 25, C 29
IV	3	C 26, C 36, C 39
V	2	C 18, C 33
VI	1	C 35
VII	1	C 41
VIII	1	C 31
IX	1	C 10
X	1	C 34

stems, large leaf area, long inflorescence and greater maturity period. Medium to high flowering period and primary branches/plant were also characteristic of this group. Majority of germplasm lines in Group I exhibited high grain yield, moderate number of inflorescence/plant and low 100- seed weight. Group II comprised 9 lines having medium to high 100- seed weight and low values for rest of the characters, including grain yield and inflorescence/plant. The 3 lines in Group III had low grain yield and less number of primary branches/plant and low values for most other traits. Group IV had three germplasm lines viz. C 26, C 36 and C 39 which exhibited high grain yield with more number of long inflorescence, medium to high primary branches/plant, plant height, stem diameter and low to medium leaf area and days to flowering. Two lines were included in Group V had low grain yield, inflorescence length and days to flowering, low to medium days to maturity and plant height, medium index value for number of primary branches/plant, leaf area and stem diameter, medium to high values for inflorescence/plant and high index value for 100 seed weight. Groups VI, VII, VIII, IX and X comprised of single germplasm line each. Group VI had high grain yield and inflorescence/plant, medium values for days to flowering, days to maturity and stem diameter and low values for the rest of the characters. The single germplasm line in Group VII exhibited high index values for inflorescence/plant, medium values for number of primary branches/plant, leaf area, 100- seed weight and low values for the rest of the characters including grain yield. The line included in Group VIII had medium value for days to flowering, days to maturity, stem diameter, number of primary branches/plant and low values for all other characters. Group IX had a single germplasm line with long inflorescence, moderate leaf area, stem diameter, plant height, inflorescence/plant, grain yield and low values for days to flowering, days to maturity, number of primary branches/plant and 100 seed weight. The single germplasm line in Group X had high days to flowering and maturity, medium leaf area, stem diameter, inflorescence/plant and grain yield while rest of the characters had low values.

The pattern of distribution of the germplasm lines in different groups indicated that genetic divergence was not related to geographical differentiation. The genotypes having geographical proximity fell in different groups and vice versa. The tendency of lines occurring in clusters cutting across geographical boundaries demonstrates that geographical isolation was not directly related to genetic diversity and had been reported in various crop species [22,23]. An interesting feature of the metroglyph analysis was the distribution of *C. album* and *C. quinoa* in different groups. Since the material is very diverse in terms of origin and ploidy levels, the scattering of these species into different groups is obvious. The 22 germplasm lines of Group I comprised bulk of *C. album* types, three lines of *C. quinoa* and three distinct species viz. *C. giganteum*, *C. ugandae* and *C. berlandieri*. Group II had four germplasm lines each of *C. album* and *C. quinoa* and one tetraploid species (*C. bushianum*) all of which had low grain yield. Group III comprised of 3 lines, which are tetraploid and native of the American subcontinent. Group IV consists of a diploid *C. album* and two exotic hexaploid lines. Group V comprised of hybrid types with low grain yield. Groups VI, VII and X contained single germplasm lines of different species. The genotypes of Groups IV, VI, IX and X had medium to high grain yield. *C. album* is an assemblage of highly heteromorphic wild and semi-cultivated forms [3,24]. The presence of *C. album* in different groups is due to the presence of varying ploidy levels (2n=18, 36,54) and poor taxonomic characterization of the species [8]. The metroglyph clearly shows that all indigenous *C. album* hexaploid types were vigorous and showed high grain yield except C 13 while the indigenous diploid *C. album* types had medium to high grain yield. Since grain is the major economically important product, the germplasm lines of groups I, IV, VI, IX and X could help in future *Chenopodium* breeding programmes for achieving higher grain yield.

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