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Research Article

Evaluation and characterization of Chilli (*Capsicum annuum* L.) germplasm for some morphological and yield characters

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Abstract

The study of genetic diversity and phenotypic variability in the available germplasm is a prelude to crop improvement. The present study was undertaken to characterize 10 accessions of *Capsicum annuum* acquired from the Centre for Genetic Resources, the Netherlands (CGN) through Plant Genetic Resources Institute (PGRI), National Agricultural Research Centre (NARC) Islamabad. The accessions were evaluated for 35 qualitative and 11 quantitative parameters. Wide variation was noted among the genotypes for important characters pertaining to fruit and seed yield. Such genetic variability can be a valuable resource for genetic improvement including developing resistance against insect pests and diseases. The available accessions need to be characterized in further detail under Pakistani agro-climatic conditions to ascertain the statistical significance of variability, understand the genetic control and gene interactions involved.

Key words: *Capsicum annum* L.; exotic germplasm; genetic variability; morphological differences.

Introduction

Pepper (*Capsicum* spp.) is one of the world's major vegetable and spice crop [1]. Globally, 1776 thousand ha land is estimated to be under cultivation of chillies producing around 7182 thousand tons. India is the largest producer of chillies in the world followed by China. Other important chilli producing countries include Pakistan, Ethiopia, Myanmar, Mexico, Vietnam, Peru, Ghana and Bangladesh. Pakistan contributes around 6% to the world's total chilli production [2]. Chilli is the third important crop of the family *Solanaceae* after tomato and potato [3]. The genus *Capsicum* includes 30 known species [4]. The five most economically notable species of chillies are C. *annuum*, C. *frutescens* L., C. *baccatum* L., C. *pubescens* Ruiz. & Pav., and C. *chinense* Jacq. [5]. Among the

cultivated species the first two seems to have been domesticated in Mesoamerica while the later three species in South America [6, 7, 8]. The plant of chilli is usually bushy 60-80cm high. It requires warm and humid climate for growth and dry weather during maturity. It is semi-perennial but usually cultivated as an annual [9].

Chilli pepper is thought to be the most popular spice with over 20% of the worlds' population using it in one or other form [10]. However in addition to culinary use (as spice, cooked vegetable, food ingredient, colorant etc.), *Capsicum* species are also used in cosmetics [4] and medicine [11]. *Capsicum* spp. contain a range of essential nutrients and bioactive compounds which are known to exhibit antioxidant, antimicrobial, antiviral, anti-inflammatory and anticancer properties [12]. Some of the known chemicals contained in *Capsicum* fruit include steam-volatile oils, fatty oils, capsaicinoids, carotenoids, vitamins, proteins, fiber and mineral elements [4]. *Capsicums* are an excellent source of Vitamins A, B, C, E and P. Fresh green chilli peppers contain more vitamin C than citrus fruits and fresh red chili has more vitamin A than carrots [13, 14].

Chilli is also an important cash crop of summer season in Pakistan, especially in Sindh and southern Punjab [9]. According to the Economic Survey of Pakistan [15] chilli crop was cultivated on a total area of 62700 hectares in 2013-14 with an annual production of 145800 tons. However, there has been a significant decline in the area under cultivation and production of chillies in Pakistan mainly because of the pests and pathogens, which cause considerable losses every year. Major insects, which attack on chilli plants, are aphids, mites, thrips etc. Among the fungal diseases, damping off, *Phytophthora* root rot, powdery mildew, *Fusarium wilt*, *Anthracnose* etc., are the most destructive [9]. Higher yield and host plant resistance genes have to be identified in the gene pool existing as land-races, wild and semi-domesticated relatives of cultivated species for exploitation in breeding programmes [16, 17]. The characterization and evaluation of accessions maintained in gene banks are of fundamental importance in this regard [11].

Since the study of genetic diversity and phenotypic variability in the available germplasm is a prelude to potential chilli crop improvement [18], therefore the present study was undertaken to characterize the available germplasm for use in breeding programmes.

Materials and methods

Characterization of 10 accessions of exotic nature was carried out at Plant Genetic Resources Institute (PGRI), National Agricultural Research Centre (NARC) Islamabad as part of a long-term project to characterize the *C. annuum* L. germplasm acquired from the Centre of Genetic Resources, the Netherlands (CGN) through the PGRI. Plants were grown in rows kept 75 cm apart. Plant-to-plant distance was kept 50 cm. Usual agronomic and plant protection practices were adopted to grow the plants in the experimental field of NARC in the year 2014.

The germplasm comprised of 10 accessions of *C. annuum* viz. 'CGN-21462', 'CGN - 17150', 'CGN-16828', 'CGN-1624', 'CGN-16936', 'CGN-17014', 'CGN-17210', 'CGN-19178', 'CGN-19189' and 'CGN-17212'. The germplasm was evaluated for 46 parameters that included qualitative (35) as well as quantitative (11). Qualitative traits were selected from plant descriptors developed by the IPGRI for *Capsicum* spp. [19]. The quantitative traits (listed in Table 1) were studied according to the standard procedure of recording data in chilli crop. Mean values were used for comparison.

Table 1. Quantitative characters studied.

S. No.	Character	Units	Remarks
1	Plant height	cm	Measured from ground level (base) to tip of the plant for 10 plants each with the help of a measuring tape
2	Leaf length	cm	10 mature leaves each from 05 randomly selected plants at mid level of the plant were measured from tip to petiole. The character is a good indicator to judge photosynthesis and general health of the plant with important bearing on yield.
3	Leaf width	cm	10 mature leaves each from 05 randomly selected plants were measured at the broadest point from middle of the plant.
4	Fruit length	cm	10 fruits each from 05 randomly selected plants were measured. Fruit length attracts customers and contributes to yield.
5	Fruit width	cm	Width of 10 fruits each from 05 randomly selected plants was measured using Vernier calliper. Fruit width attracts customers and contributes to yield.
6	Fruit weight	g	Weight of 10 individual fruits each from 05 randomly selected plants was measured using electronic balance. Fruit weight attracts customers and contributes to yield.
7	Fruit pedicel length	cm	Length of 10 flowers each from 05 randomly selected plants was measured using a scale. Long pedicel may expose the fruit to sunlight.
8	Fruit wall thickness	mm	Thickness of fruit wall of 10 fruits each from 05 randomly selected plants was measured using Vernier caliper. Thickness of fruit wall can be important with regards to attack of insect pests on the fruit.
9	No of locules	Numbers	Number of locules was counted in 10 fruits each from 5 randomly selected plants.
10	Seed diameter	cm	Seed diameter of 10 seeds each from 5 randomly selected plants was measured using Vernier caliper. Seed diameter a useful indicator of viability of the seed.
11	No of seeds per fruit	Numbers	Seeds were counted from 10 fruits each of 5 randomly selected plants. Number of seeds in fruits indicates the success of pollination and fertilization.

Results and Discussion

The current paper reports the preliminary evaluation of *C. annuum* germplasm, which were originally obtained from the Centre of Genetic Resources, the Netherlands (CGN); has collection of diverse *Capsicum* species [20]. The materials were evaluated for 35 qualitative descriptors selected from those developed by IPGRI [19] and also previously used by [21] and [8]. The results show that with regards to the following qualitative characters all the accessions were found to be similar (Table 2(a)).

However, the genotypes exhibited variation with respect to the following qualitative traits (Table 2(b)).

Table 2 (a). Qualitative characters which were similar in all accessions.

No	Character	Phenotype	No	Character	Phenotype
a	Life cycles	Annual	f	Anthocyanin spots on corolla	Present
b	Stems	Green	g	Neck at the base of fruit	Absent
c	Nodal anthocyanin	Green	h	Ripe Fruit persistence	Slight
d	Calyx pigmentation	Present	i	Fruit appendage at blossom:	Absent
e	Calyx annular pigmentation	Present	j	Pedicel with stem	Persistent

Table 2 (b). Qualitative characters which were found to be variable.

S. No.	Character	Phenotypic expression
1	Stem shape	Angular or cylindrical
2	Stem pubescence:	Intermediate or dense
3	Plant growth habit	Prostrate or erect
4	Tillering	Sparse, intermediate or dense
5	Branching habit	Prostrate, intermediate and dense
6	Leaf density	Intermediate, dense
7	Leaf colour	Light green, green, dark green
8	Leaf shape:	Ovate, lanceolate
9	Lamina margin	Ciliate, intermediate, entire, undulate
10	Leaf pubescence	Intermediate, dense
11	Flower position	Pendant, intermediate, erect
12	Corolla colour	White, light green, green
13	Corolla spot colour	Green, yellow green
14	Calyx margin	Entire, intermediate, dentate
15	Fruit colour (intermediate stage)	Dark purple, yellow, light red, dark red
16	Fruit colour (at maturity):	Purple, dark red
17	Fruit shape	Cordated, blocky, elongated
18	Fruit shape at pedicel attachment	Cordated, truncated, obtuse
19	Fruit shape at blossom	Sunken, pointed, sunken and pointed
20	Fruit cross sectional corrugation	Slightly corrugated, corrugated and intermediate
21	Fruit surface	Smooth, wrinkle
22	Pedicel with fruit	Persistent, intermediate
23	Seed colour	Brown Light brown
24	Seed surface	Rough, smooth
25	Seed size	Small, intermediate and large

The genotypes were also evaluated for 11 quantitative traits as presented in Table 3. It can be seen from the table that wide variation existed among the genotypes with regard to the traits studied. For example plant height ranged from 33.9 cm ('CGN-21462') to 64.5 cm ('CGN-17150'), mean fruit weight ranged from 1.4 g ('CGN-19212') to 57.3 g ('CGN-17210'). Similar range of variability was observed for all the quantitative characters evaluated. It can be seen from the table that accession no. 'CGN-17014' performed poorest for important characters that contribute to fruit yield (leaf length, leaf width) or seed yield (number of locules, no. of seeds per fruit). On the other hand accession no. 'CGN-17150' (plant height, fruit width) and 'CGN-17210' (leaf length, fruit weight) showed maximum values for important characters having a bearing on fruit yield [22].

Table 3. Mean max and min values for different characters among the 10 accessions

Character	Min. value	Genotype	Max. value	Genotype
1. Plant height	33.9 cm	'CGN-21462'	64.5 cm	'CGN-17150'
2. Leaf length	3.7 cm	'CGN-17014'	10.5 cm	'CGN-17210'
3. Leaf width	1.5 cm	'CGN-17014'	6.4 cm	'CGN-19189'
4. Fruit length	4.0 cm	'CGN-19178'	10.9 cm	'CGN-21462'
5. Fruit width	1.0 cm	'CGN-19212'	6.1 cm	'CGN-17150'
6. Fruit weight	1.4 g	'CGN-19212'	57.3 g	'CGN-17210'
7. Pedicel length	1.3 cm	'CGN-19212' 'CGN-19189'	2.5 cm	'CGN-17210' 'CGN-16936'
8. Fruit wall thickness	0.7 mm	'CGN-19212'	5.1 mm	'CGN-19189'
9. No. of locules	2.0	'CGN-17014'	4.3	'CGN-16924'
10. Seed diameter	0.5 cm	'CGN-16828'	1.2 cm	'CGN-21462'
11. No. of seeds per fruit	31.7	'CGN-17014'	243.3	'CGN-21462'

The high diversity in collection shows a great potential for improvement of agronomic traits in pepper [8]. High heritability for characters like fruit yield, fruit weight, fruits per plant, number of branches per plant, fruit diameter, pericarp thickness, pedicel diameter etc has been reported by previous workers such as [23, 24, 25].

The wide variation in the present investigation is supported by previous workers. Wide range of variability for a number of characters had been reported [26]. They had also noted positive correlation among certain characters which can be important for genetic improvement for example plant height has been reported to have a positive correlation with pedicle length [26]. Wide variation has also been reported among chilli genotypes by [8, 23, 26, 27]. Some of the characters have been reported to be responsive to direct selection like fresh fruit weight, fruits per plant etc [23].

It is concluded that the accessions available in gene bank of PGRI possess wide variation for important characters as they have been obtained from different local and exotic origins. Moreover, the germplasm acquired from the CGN has shown potential variation. Such genetic variability can be a valuable resource for genetic improvement [17]. The available accessions need to be characterized in detail under Pakistani agro-

climatic conditions to ascertain the statistical significance of variability, understand the genetic control and associations involved. In addition to other valuable characters contributing to yield, genetic resistance to diseases and pests can be the primary weapon to save the colossal losses in yield of chillies [28] which can also be useful in Pakistan where the area and production has seen significant decline due to insect pest and disease attacks [12]. Characterization of germplasm, especially that already available in gene banks can unearth genetic sources of resistance to insect pests and diseases [11].

Table. 4. Mean values recorded for 11 quantitative characters.

Genotype	Pl. Ht. (cm)	Lf. L (cm)	Lf. Wd (cm)	F.L (cm)	F. Wd (cm)	F. Wt. (g)	P.L (cm)	W. T (mm)	Lc (Nos)	S. Dia (mm)	S/F (Nos)
'CGN-21462'	33.9	9.7	4.8	10.9	3.7	43.1	2.4	2.5	3.0	1.0	243.3
'CGN-17150'	64.5	5.7	3.3	8.1	6.1	5.8	2.3	3.6	3.7	0.5	112.0
'CGN-16828'	42.7	6.2	5.9	4.3	5.2	28.8	2.0	2.3	3.0	0.9	56.3
'CGN-16924'	38.1	7.0	3.7	5.4	4.7	47.3	2.0	3.5	4.3	0.9	107.7
'CGN-16936'	42.9	8.3	3.8	6.9	1.9	14.8	2.5	2.9	3.0	0.8	95.0
'CGN-17014'	58.4	3.7	1.5	4.4	4.2	2.8	1.8	0.8	2.0	0.7	31.7
'CGN-17210'	54.4	10.5	5.5	8.6	4.3	57.3	2.5	3.7	3.3	1.0	119.0
'CGN-19178'	39.8	9.2	5.2	4.0	5.4	49.3	2.1	3.9	4.0	0.9	62.7
'CGN-19189'	59.1	10.2	6.4	5.0	5.1	39.2	1.3	5.1	3.0	0.9	55.0
'CGN-19212'	42.3	4.8	2.8	4.1	1.0	1.4	1.3	0.7	2.3	1.2	37.3

(**Pl. Ht** = Plant Height, **Lf. L**= Leaf Length, **Lf. Wd** = Leaf Width, **F.L** = Fruit Length, **F. Wd** = Fruit Width, **F. Wt** = Fruit Weight, **P. L** = Pedicel Length, **W. T** = Fruit Wall Thickness, **Lc** = No. of Locules, **S. Dia** = Seed Diameter, **S/F** = Seeds per Fruit).

Authors' contributions

Conceived and designed the experiments: W Quresh & SA Jatoi. Performed the experiments: W Quresh. Analyzed the data: M Alam, H Ullah. Contributed reagents/materials/analysis tools: W Khan. Wrote the paper: H Ullah, M Alam.

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