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Wei SHI
1 Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China; 2 Turpan Eremophytes Botanic Garden, Chinese Academy of Sciences, Turpan 838008, China;,
water5116@163.com

BoRong PAN
1 Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China; 2 Turpan Eremophytes Botanic Garden, Chinese Academy of Sciences, Turpan 838008, China;

Habibullo SHOMURODOV
3 Scientific Center of Plant Production "Botanika", Uzbek Academy of Sciences, Tashkent 32, Uzbekistan

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Correlation of soil properties and fruit size of *Calligonum mongolicum* and related species

Wei SHI[1,2*], BoRong PAN[1,2], Habibullo SHOMURODOV[3]

[1] Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China;
[2] Turpan Eremophytes Botanic Garden, Chinese Academy of Sciences, Turpan 838008, China;
[3] Scientific Center of Plant Production "Botanika", Uzbek Academy of Sciences, Tashkent 32, Uzbekistan

Abstract: Correlations of soil properties and fruit size of *Calligonum mongolicum* Turcz. and related species were analyzed. The results showed that the particle size characteristics of soils for growing *Calligonum mongolicum* and related species were similar, and the soils belonged to sandyones. The organic matter contents of soils were low (averaging 1.772 to 3.054 g/kg), and the total salt content of soils was low too (averaging 0.471 g/kg). The pH values indicated that the soils were alkaline, varying from pH 7.65 to 10.25. The results of Principal Component Analysis (PCA) and hierarchical cluster showed that 9 habitats could be divided into 6 types according to salt contents and pH values. Fruit sizes of different populations and the soil properties had significant linear correlations (P<0.000). It was concluded that the differences in fruit sizes among the populations of *Calligonum mongolicum* and related species were related to soil variability, especially the nutrient contents of soils, and fruit size can not be considered as a taxonomic index of *Calligonum mongolicum* and related species.

Keywords: *Calligonum mongolicum*; related species; soil properties; fruit size; correlation

Plants are sensitive to environmental change and correlated with many factors (Preston, 1962). The situation of environment modification was studied in some classical taxonomic works in the early 1900s (Turesson, 1922; Clausen and Keck, 1940). However, the significance of environmental modification has not been granted sufficient importance (Davis, 1983). On one hand, environmental modification allows biological variation and is a method for adaptation to environments (Stebbins, 1950; Grant, 1991). On the other hand, although environmental modification has no genetic basis, the variability and pattern of plant species is controlled by environmental modification, thus determining which portion of variability is arisen by either the environment or genes is not easy (Bradshaw, 1965; Morisset and Boutin, 1984; Xu, 1986). Thus, it is important to understand environment modifications and adaptation characters of plants when studying plant variability and taxonomy and when choosing or weighting characters (Bradshaw, 1965; Grant, 1991), and thus it is unreasonable to ignore modifications and adaptations of characters when making rational taxonomic decisions (Davis and Heywood, 1963; Davis, 1983). Species distribution usually has greater genetic variability. The fruit or seed is one of the most important taxonomic characters (Miehelle *et al*., 1995), and it is worthwhile to study its taxonomic value and environmental modification.

Calligonum mongolicum Turcz. (Polygonaceae) has complex taxonomic relationships with some species, inter-related distributional areas as well as disputed taxonomic relations with other species (Mao and Pan, 1986). Previous studies suggested that there are variable and overlapping states among fruit morphologies for *C. mongolicum* as well as other species in the genus, *C. pumilum*, *C. gobicum*, *C. chinense*, *C.*

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*Corresponding author: Wei SHI (E-mail: water5116@163.com)

alashanicum, C. roborowskii and *C. zaidamense* (Shi, 2009). The fruit characters can not be used in taxon of the genus (Shi, 2009). As well, the related species and *C. mongolicum* have slightly different karyotypes (Shi, 2009). Based on the similarity of karyotypes and ambiguity of fruit characters, we have suggested merging *C. pumilum* into *C. mongolicum* (Shi *et al*., 2009). However, the fruit characters, especially those of taxonomic significance, such as fruit size, have been the classical taxonomic evidence used in Flora of China (Bao and Alisa, 2003) and have been in use for some time. There are few studies on the soil physical and chemical properties of the habitats for *Calligonum* (Tan *et al*., 2008a, b). This paper examined the relationship between soil physical and chemical properties of the habitats and the taxonomic indices of fruit sizes in arid deserts. Although fruit size, as a taxonomic index, is used by many taxonomists, it remains to be an uncertainty whether it is really appropriate for *Calligonum mongolicum* and related species, and whether they are in fact the same species. Thus this paper sets out to provide reasons for the differences in fruit sizes in different populations of *Calligonum* and to overturn the use of fruit size as a taxonomic index.

1 Materials and methods

1.1 Materials

From July 31 to August 31, 2006, *C. mongolicum* populations and related species were investigated in Inner Mongolia, Ningxia, Gansu and Xinjiang (Table 1). Longitude, latitude and altitude were recorded. Moreover, to obtain specimens, we used the quadrat method (10 m×10 m) (Song, 2001) and collected soil from three locations (from two corners and the middle along the diagonal of the quadrat). The 0–100 cm depths of soil from dune areas were measured in order to compare and analyze the characteristics of soil contents at different positions. Specimens were identified using characters from their external morphologies. Specimens are preserved in the Herbarium of the Xinjiang Institute of Ecology and Geography, CAS. The information for the eight species is shown in Table 1.

1.2 Methods

Soil particle size was measured by the densimeter method; organic matter content using the $K_2Cr_2O_7$ method (GB9834–88); total N using $CuSO_4$–Sepowder diffusion method (GB7848–87); total P using the NaOH Melting—Ascorbic acid-molybdenum blue spectrophotometric method; total K using the NaOH Melting–Flaming luminosity method (GB7854–87); available N using the Alkali hydrolization–diffusion method; available P using the 0.5 mol/L $NaHCO_3$ Leaching––Ascorbic acid-molybdenum blue spectrophotometric method; and available K using the 1 mol/L NH_40Ac Leaching–flaming luminosity. Soil pH was measured using PHS–2C digital acidometer (520005, Shanghai Experiment Reagent Company); soil EC (electronic conductivity) was measured using DDS–307 conductometer; total soil salt content was measured using the weight method (Cheng *et al*., 2007).

Ten individual plants were selected from each population of *C. mongolicum* and related species. The roots of *Calligonum* are able to produce ramets, so a 40-m space was retained between individuals during sampling in order to avoid sampling the same individual twice (Zhang and Wang, 2005). Ten fruits were selected from each plant and the length (LF) and width of the fruit (WF) were measured to calculate fruit size (FS= LF×WF).

Table 1 Location for growing *C. mongolicum* and related species

Species	No.	Location	Lat.	Lon.	Alt. (m)	Spec. No.	Voucher
	M1	Erlianhaote, Inner Mongolia	112°03′E	43°45′N	898.3	06005–06014	Borong Pan
C. mongolicum	M2	Qingtongxia, Ningxia	105°55′E	38°01′N	1,134	06020–06029	Borong Pan
	M3	Erjinaqi, Inner Mongolia	100°26′E	41°27′N	1,003	06056–06067	Borong Pan
C. pumilum	P1	Hami, Xinjiang	091°32′E	43°23′N	1,038	05010–05019	Borong Pan
C. chinense	C1	Zhangye, Gansu	100°18′E	39°28′N	1,458	06113–06122	Borong Pan
C. gobicum	G1	Erjinaqi, Inner Mongolia	100°27′E	41°43′N	969.8	06047–06056	Borong Pan
C. alashanicum	A1	Minqin, Gansu	102°52′E	38°34′N	1,369	06173–06193	Borong Pan
C. zaidamense	Z1	Zhangye, Gansu	100°18′E	39°03′N	1,458	06103–06112	Borong Pan
C. roborowskii	R1	Luntai, Xinjiang	083°55′E	41°49′N	1,019	05025–05034	Borong Pan

Morphological traits were analyzed using each population as the operational taxonomy unit (OTU). All numerical analyses were based on standardized data. Principal component analysis (PCA) was used based on the correlation matrix of numerical characters and UPGMA (Unweighted Pair-Group Method with Arithmetic means) cluster using the square Euclidean distance coefficient performed by the STATISTICA software package (Tao and Ren, 2004).

3 Results

3.1 Particle size characteristics of soils

The soils for growing *C. mongolicum* and related species were composed of predominantly coarse sand and medium-sized sand, which accounted for 9.86%–53.00% and 1.99%–50.89%, respectively. Extremely coarse sand, extremely fine sand and fine sand accounted for 1.03%–36.08%, 1.99%–50.89% and 0.44%–22.63%, respectively, and clay with the particle sizes smaller than 0.005 mm was almost zero, silt with the particle sizes of 0.050–0.005 mm only made up 0.02%–9.46% and gravel with the particle size bigger than 2.00 mm only 0–11.11%, respectively (Table 2). Material composition analysis of the soils revealed that particle size distribution varied with different plant communities. The following patterns could be discerned (Table 2): the sand (0.05–2 mm) in the soils accounted for 96.54%–100%. According to the USDA soil textural triangle (Qian *et al*., 2009), we concluded that all of them were coarse sand soils that had good ventilation and water permeability, but had poor ability to hold water and plant nutrients (Lin, 2002). There were similar proportions of particle sizes between the soils growing *C. mongolicum* and related species; the greater proportions were also coarse sand and medium-sized sand with the percentage of 9.86%–53.00% and 4.84%–51.51%, respectively. A comparison of soil composition at different soil depths revealed that there was no significant difference in the particle size distribution among the soils growing *C. mongolicum* and related species.

3.2 Nutrient contents of soils

There were significant differences in the nutrient contents in 0–30 cm depth of soils ($P<0.05$). The organic matter contents were 0.529–5.468 g/kg; total N, P and K were 0.063–0.513, 0.194–0.772 and 13.980–25.799 g/kg, respectively; available N, P, K were 0.003–0.027, 0.001–0.005 and 0.050–0.180 g/kg, respectively (Fig. 1). Organic matter contents in the soils growing *C. mongolicum* and related species were low and varied with the averages of 1.772–3.054 g/kg, reflecting low accumulation of organic matter. The organic matter contents of the populations at Erlianhaote (M1), Qingtongxia (M2), and Erjinaqi (M3) were higher than those associated with the other species. Both the organic matter contents of M2 were highest among these populations, reaching up to 5.468 and 9.427 g/kg. The values for total N, P, K and available N, P, K of the sites at Erlianhaote (M1), Qingtongxia (M2), and Erjinaqi (M3) were higher than those at the other sites (Fig. 1a).

Table 2 Soil particle size characters of the soils for growing *C. mongolicum*, *C. pumilum*, *C. chinense*, *C. gobicum*, *C. alashanicum*, *C. zaidamense* and *C. roborowskii*

Site	Clay (<0.005 mm)	Silt (0.050–0.005 mm)	Extreme fine sand (0.125–0.050 mm)	Fine sand (0.25–0.125 mm)	Medium sand (0.25–0.5 mm)	Coarse sand (0.5–1 mm)	Extreme coarse sand (1–2 mm)	Gravel (>2 mm)
				(%)				
M1	0.00±0.00	0.90±0.27	6.90±3.30	2.80±1.53	25.32±3.05	40.73±5.54	20.96±3.27	2.40±1.65
M2	0.00±0.00	4.21±2.42	14.55±6.47	14.43±1.7	41.28±3.70	18.59±0.59	5.08±4.01	1.49±2.11
M3	0.00±0.00	3.94±1.21	22.51±12.87	11.65±5.67	21.93±13.58	18.50±4.33	17.06±8.63	4.42±4.79
P1	0.00±0.00	8.20±0.95	47.25±3.04	8.33±3.20	8.62±2.87	12.56±3.46	11.80±4.55	3.32±4.28
C1	0.00±0.00	0.59±0.41	3.05±0.75	7.17±9.34	26.34±18.13	40.16±15.74	21.74±11.83	0.95±1.29
G1	0.00±0.00	4.09±2.48	14.90±7.27	17.68±3.68	43.45±6.85	17.33±0.97	2.39±0.99	0.17±0.24
A1	0.00±0.00	2.53±1.23	10.43±3.91	8.88±3.84	32.35±6.67	31.40±4.45	13.91±2.68	0.50±0.51
Z1	0.00±0.00	2.27±1.81	14.05±11.34	5.74±4.38	20.60±10.81	34.84±7.87	19.70±11.61	2.83±4.00
R1	0.00±0.00	3.15±0.69	22.68±6.84	10.26±5.25	18.59±1.09	21.06±6.44	17.57±4.83	6.68±1.84

Note: data are mean±SD, n=10.

Comparison of CV of the nutrients in the soils revealed that all of the contents of organic matter, total N, P, K and available N, P, K had similar variabilities, ranging from 23.69% to 56.97%.

The analysis showed that the organic matter contents at the depth of 0–7, 7–42 and 42–63 cm from the soils were higher than at the depth of 63–100 cm. At the depth of 0–7 cm, the organic matter content of M2 was highest, and at the depth of 63–100 cm in Hami (P1) was highest among the populations (Fig. 1a). The total N analysis showed that the total N content was higher at the depth of 0–7 cm than at other depths, the total N content was highest at the depth of 0–7 cm in Qingtongxia (M2) and that at depth of 63–100 cm in Hami (P1) was highest among the 7 populations (Fig. 1b); The total P contents of soil in Hami (P1) are higher at the depth of 7–42, 42–63 and 63–100 cm (Fig. 1c). The total K contents of M1 among populations were highest at every soil layer, comparing with other soil nutrients (Fig. 1d).

The results of pH analysis showed that the soils of these 7 populations were alkaline with pH values varying from 7.65 to 10.25 (Fig. 2a). At every depth of soils on dune slopes, the value of M1 was higher than the others; the values of pH in Qingtongxia (M2) were similar (8.40–8.59) with the values of that in Erjinaqi (M3) at the depth of 0–7, 7–42 and 42–63 cm (8.15–8.62); pH at the depth of 63–100 cm at M3 was very slightly lower (7.92). However, the difference was not great; other populations had a similar situation, that is, the pH values (7.65–8.77) were similar at different soil depths, revealing that soil eluviations were very limited (Fig. 2a). Soil EC in the region varied with a range of 0.05–0.93 ms/cm (Fig. 2b). At the depth of 0–7 cm, the soil EC values in Erjinaqi (G1) (0.93 ms/cm) and that in Hami (P1) (0.75 ms/cm) were slightly higher than the others; the soil EC in all 7 populations were similar (0.09–0.15 ms/cm) at the depths of 7–42 cm and 63–100 cm; at the depth of 42–63 cm, that in Erlianhaote (M1) (0.79 ms/cm) was slightly higher than the others, but the others were similar to each other (0.09–0.26 ms/cm). The change pattern in soil EC was different from that of pH value (Fig. 2b).

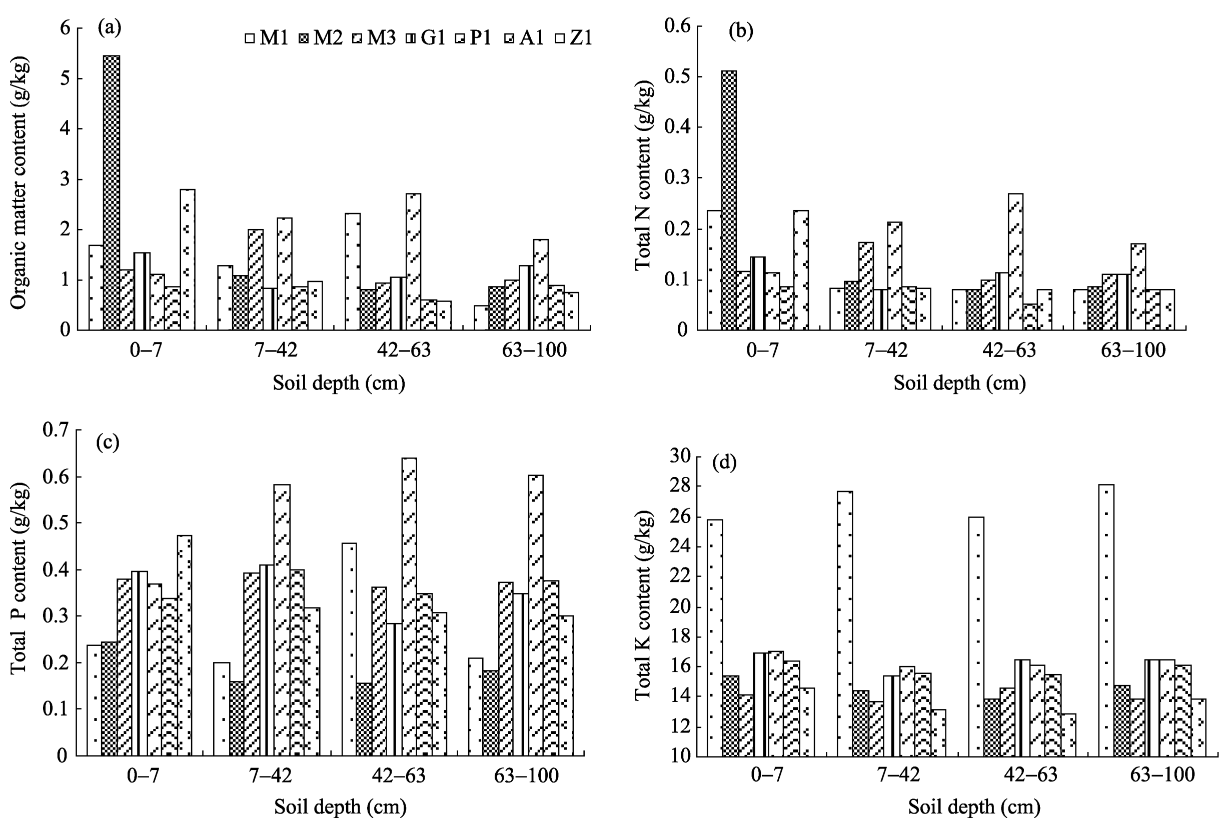

Fig. 1 Organic matter contents and total N, P, K variations along with depths of soils for growing *C. mongolicum, C. pumilum, C. gobicum, C. zaidamense* and *C. alashanicum*

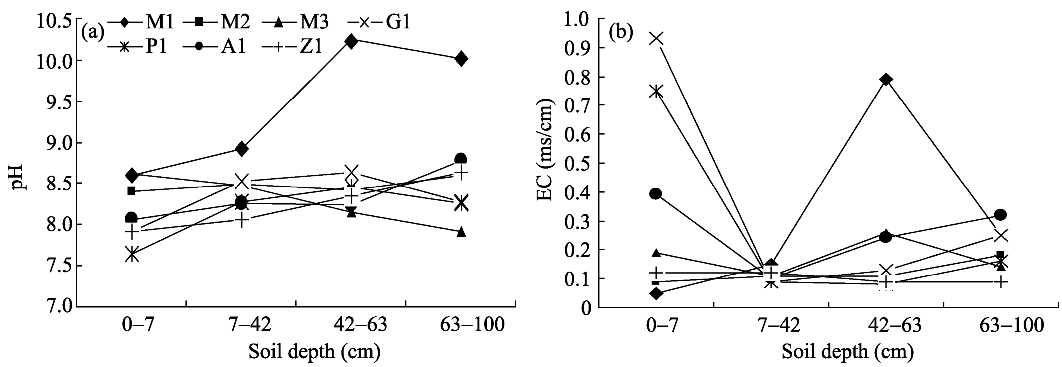

Fig. 2 The pH value and electric conductivity variations (EC) along with depths of soils growing *C. mongolicum, C. pumilum*, *C. gobicum*, *C. zaidamense* and *C. alashanicum*

3.3 Classification analysis based on soil properties

Through the above survey results, it could be seen that the soil particle size distribution, plant nutrient contents, pH and EC in soil sites under *Calligonum mongolicum* and related species were similar. Consequently, we carried out a classification analysis of populations based on soil nutrients.

The analysis revealed that the first two PCA axes were consistently 81.76%, which explained the variation with salt contents for each population. The PCA ordination according to the first two PCA axes (Fig. 3) was relatively consistent with the hierarchical cluster (Fig. 4), which also accounted for the species differences and geographical distribution of the 7 populations. The 9 habitats could be divided into 6 types according to the salt content and pH value diversiform. The populations in Erlianhaote (M1), Qingtongxia (M2) and Erjinaqi (M3) could be classified as one type; those in Zhangye (Z1 and C1) also belonged to one type, which was close to the *C. mongolicum* populations (M1, M2 and M3); that of Hami (P1) was also near that of populations in *C. mongolicum* (M1, M2 and M3). It seemed that the sites in Luntai (R1) and Erjinaqi (G1) were comparatively independent of the others and that in Minqin (A1) was close to the *C. mongolicum* populations, which accorded with their relatively close geographical distribution (Figs. 3 and 4).

3.4 The correlation of soil characters and fruit size

Fruit size has been used as a key taxonomic character to distinguish *C. mongolicum* and related species (Mao and Pan, 1986; Bao and Alisa, 2003), but we found there were variable and overlapping states among the morphologies of *C. mongolicum* and related species, especially in the key taxonomic character of fruit size. Fruit characteristics can not be used as a straightforward and feasible taxonomic test for species differentiation. Based on these results, we suggested that these

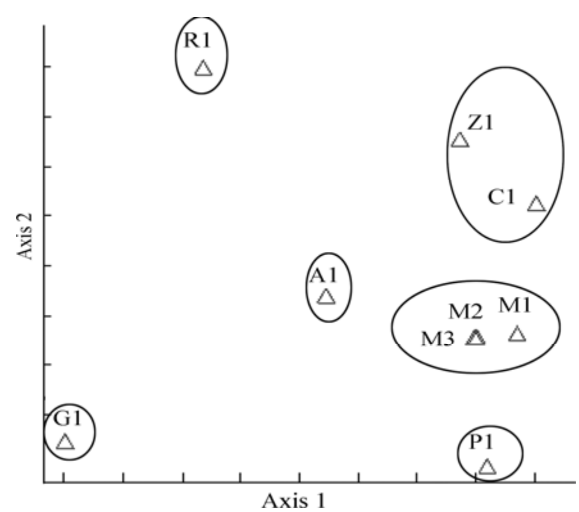

Fig. 3 PCA ordination map for pH and salt of soil growing *C. mongolicum*, *C. pumilum*, *C. gobicum*, *C. chinense*, *C. zaidamense* and *C. alashanicum*

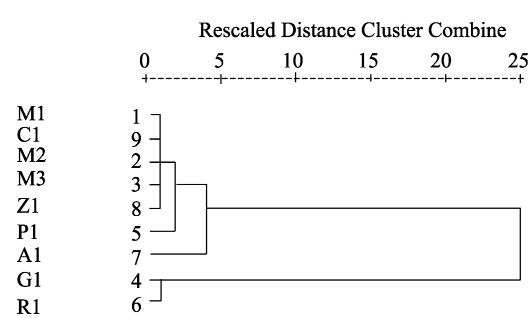

Fig. 4 The hierarchical cluster map for pH and salt of soil growing *C. mongolicum*, *C. pumilum*, *C. gobicum*, *C. chinense*, *C. Zaidamense*, *C. alashanicum*, *C. roborowskii* and *C. alashanicum*

six species (*C. gobicum*, *C. chinense, C. pumilum, C. alashanicum*, *C. zaidamense, C. roborowskii*) should be merged with *C. mongolicum* (Shi *et al.*, 2010).

The studies showed that there were differences of soil physical and chemical properties between sampling sites of *Calligonum* populations. Accordingly, any correlation between soil physical and chemical properties and fruit size (Table 3) can be found using the Pearson Coefficient of Correlation Analysis (Table 4).

The results showed that all the soil parameters of proportions of coarse sand and medium-sized sand, total N, P, K, available N, P, K, pH and EC had significant linear correlations (P<0.05) with fruit size. The fraction proportions of coarse sand and medium-sized sand are the greatest in terms of soil particle size distribution and also had significant linear correlation (r=0.561; P=0.000) with fruit size. Total salt content and organic matter content were selected because they were the first two PCA axes that explained 81.76% of the variation between sites. It was shown that fruit size of different populations and the total salt content in the underlying soil had a significant linear correlation (r=0.429, P=0.000), and fruit size and soil organic matter content had a significant linear correlation (r=0.248, P=0.000).

Table 3 The fruit sizes of *C. mongolicum*, *C. pumilum*, *C. chinense*, *C. gobicum*, *C. alashanicum*, *C. zaidamense* and *C. roborowskii*

	M1			M2			M3		
Fruit size (cm)	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
	0.342	0.613	0.155	1.05	1.959	0.155	0.777	1.904	0.196
	P1			C1			G1		
Fruit size (cm)	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
	0.936	1.285	0.76	1.226	1.881	0.604	0.817	1.207	0.094
	A1			Z1			R1		
Fruit size (cm)	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
	1.711	2.802	0.908	1.996	3.136	1.036	1.722	1.522	2.365

4 Discussion and conclusion

Generally, the poorer the sorting of deposits and the finer the soil particle size, the weaker soil osmosis will be (Zhu and Ding, 1991). Former studies have shown that the soil types associated with both five *Calligonum* species in the Tarim Basin (Gulinuer, 2008) and *C. ebi–nuricum* (Zhang, 2007) were sand soil, which is consistent with our studies. It was determined that *Calligonum* favours sandy soil. *C. mongolicum* and related species have a wide distribution, but were found most frequently on the type of sandy soil.

The pH value affects plant development and community distributions (Lin, 2002). The soil pH value at the depth of 0–7 cm, growing *C. ebi–nuricum*, was found to be 8.90 (Zhang, 2007) and that of soil for growing 5 *Calligonum* species in the Tarim Basin was 8.48 on average (Gulinuer, 2008). Both of these mean values are higher than the pH we recorded under *C. mongolicum* and related species (8.28). The range of the soil pH values in the Tarim Basin was from 7.59 to 9.10, greater than that we found under *C. mongolicum* and related species (7.65–8.62) which has a larger geographic distribution though. Thus, the soil pH values we found at the depth of 0–7 cm for *C. mongolicum* and related species were relatively narrow. The groundwater, containing abundant salts, ascends along continuous soil capillaries, which leads to the gradual accumulation of salinity in the form of a salt crust on the soil surface (Arias *et al.*, 2005). The salinization in soils growing 5 *Calligonum* species is from mild to moderate in the Tarim Basin (Gulinuer, 2008). *C. ebi–nuricum* is not distributed according to the salinity of the soil in which it is growing (Zhang, 2007). The total salt content is highly variable geographically, and

Table 4 The Pearson Correlation between soil physical and chemical properties and fruit sizes of *C. mongolicum*, *C. pumilum*, *C. gobicum*, *C. chinense*, *C. zaidamense* and *C. alashanicum*

Soil property	Organic matter	Total N	Total P	Total K	Available N	Available P
Pearson Correlation	0.248	0.362	0.115	0.513	0.103	0.523
Sig. (2–tailed)	0.000	0.000	0.005	0.000	0.006	0.000
Soil property	Available K	pH	Electric conductivity	Total salt	Coarse sand	Medium-sized sand
Pearson Correlation	0.456	0.492	0.102	0.429	0.561	0.562
Sig. (2–tailed)	0.000	0.000	0.007	0.000	0.000	0.000

differs significantly among species of *Calligonum* L. Former studies have shown that there are significant differences in plant soil salinities. In contrast, the differences among populations of the same species are not significant. Connecting with the analysis of fruit characters of *C. mongolicum* and related species (Shi *et al*., 2010), we consider that the similar conditions of soil pH and EC for *C. mongolicum* and related species may be caused by genetic factors, that is to say *C. mongolicum* and related species may be the same species distributed widely on similar soils.

Organic matter content occupies a small fraction of the total soil matter, however, it can distinctly affect the supply of plant nutrients, and influence soil buffer action (Ehrenfeid and Neal, 2002). The soil organic matter content we measured was relatively low, which accords with the results of former studies on other species in *Calligonum* L. (Zhang, 2007; Gulinuer, 2008; Tan *et al*., 2008b), but that for soil growing *C. mongolicum* and related species had a wider range of 0.912–9.427 and 0.529–5.468 g/kg. Previous research showed that the larger the distribution range of a species, the wider the range of organic matter contents (Zhang, 2007; Gulinuer, 2008; Tan *et al*., 2008b). Our studies suggested that the greatest variability is reflected in *C. mongolicum* and related species.

Total N, P, K, available N, P, K, pH, EC, organic matter and total salt of soils showed significant linear correlation (P<0.01) with fruit size of *C. mongolicum* and related species, yet fruit size has been taken as the most important taxonomic index to differentiate these species of *Calligonum*. With respect to our previous researches, concerning taxonomic relationship via studying fruits and chromosome similarities (Shi *et al*., 2009; Shi *et al*., 2010), it can now be concluded definitely that the variability is due not to genetic differences but to differences caused by geographic distribution and soil micro-condition changes, which further strengthens the opinion that all indices concerning related species of *C. mongolicum* should be combined for studies on a reasonable basis (Shi, 2009). Because phenotypic variability can be affected by both genetic factors and environmental conditions, the differences in characters of high phenotypic plasticity are almost exclusively caused not by their genetic relationships but by environment (Davis, 1983; Xu, 1986). In order to validate this point of view however, controlled experiments are needed urgently. The *Calligonum* species have therefore been planted in the Germ Resources Garden of *Calligonum* which can provide future material for controlled experiments. We hope this paper provides some new ideas concerning past taxonomic indices and how to treat them appropriately.

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References

Arias M E, Gonzalez–Perez J A, Gonzalez–Vila F J. 2005. Soil health—a new challenge for microbiologists and chemists. International Microbiology, 8(1): 13–21.

Bao B, Alisa E G B. 2003. *Calligonum* Linnaeus. In: Flora of China. Beijing: Science Press+ Sr.Louis: MBG Press, 5: 277–350.

Bradshaw A D. 1965. Evolutionary significance of phenotypic plasticity in plants. Advances in Genetics, 13 (1): 115–155.

Cai Y, Wang X, Song Y. 1999. Variation of fruit size and its shape of *Cylcobalanopsis glauca* in the eastern subtropical zone, China. Acta Ecological Sinica, 19(4): 581–586.

Chen G Q, Huang H W, Crawford D J, *et al*. 2009. Mating system and genetic diversity of a rare desert legume *Ammopiptanthus nanus* (Leguminosae). Journal of Systematics and Evolution, 47(1): 57–66.

Cheng Y, Wang Q, Li W H, *et al*. 2007. Microbiotic crusts and their interrelations with environmental factors in the Gurbantonggut Desert, Western China. Enviroment Geology, 52: 691–700.

Clausen J D, Keck D D, Hiesey W M. 1940. Experimental studies on the nature of species. I: Effect of varied enviroments on Western North American plants. Washington: Publications of the Carnegie Institute of Washington. No. 520.

Davis J L. 1983. Pheaotypic plasticity and the selection of taxonomic characters in *Puccinellia* (Poaceae). Systematic Botany, 8(4): 341–353.

Davis P H, Heywood V H. 1963. Principles of Angiosperm Taxonomy. Edinburgh and London: Oliver & Boyd. 1–665.

Ehrenfeid J G, Neal S. 2002. Invasive species and the soil effects on organisms and ecosystem progress. Forest Ecology Management, 17(1): 309–320.

Grant V. 1991. The Evolutionary Progress, a Critical Study of Evolutionary Theory. New York: Columbia University Press, 1–487.

Greipsson S, Davy A J. 1995. Seed mass and germination behaviour in populations of the dune—building grass *Leymus arenarlu*. Acta of Botany, 76(1): 493–501.

Gulinuer S. 2008. Study on endemic species of *Calligonum* in Tarim Basin. Ph.D Thesis. Urumqi: Xinjiang Institute of Ecology and Geography, CAS.

Hunt M E, Floyd G L, Stout B B. 1979. Soil algae in field and forest environments. Ecology, 60(2): 362–375.

Lin D. 2002. Soil Science. Beijing: Chinese Forestry Press, 3–156

Mao Z, Pan B R. 1986. The classification and distribution of the genus *Calligonum* L. in China. Acta Phytotaxonomica Sinica, 24(2): 98−107.

Miehelle R L, Westoby M, Jurado E. 1995. Correlates of seed size variation: a comparison among five temperate floras. Journal of Ecology, 83(1): 517–530.

Morisset P, Boutin C. 1984. The Biosystematic Importance of Phenotypic Plasticity. In: Grant W E. Plant Biosystematics. London: Acadeic Press, 293–306.

Preston F W. 1962. The canonical distribution of commonness and rarity, Part II. Ecology, 43(2): 410–432.

Qian Y B, Wu Z N, Yang H F, *et al*. 2009. Spatial heterogeneity for particle size distribution of eolian sand soil in the southern Gurbantunggut Desert. Arid Land Geography, 32(5): 655–661.

Shi W. 2009. The taxonomic study on the *Calligonum mongolicum* and its related species. Ph.D Thesis. Urumqi: Xinjiang Institute of Ecology and Geography, CAS.

Shi W, Pan B R, Duan S, *et al*. 2010. Difference Analysis on the fruit morphological characteristics of *Calligonum mongolicum* and its related species. Journal of Deserat Research, 31(1): 121−128.

Shi W, Pan B R, Gaskin J F, *et al*. 2009. Morphological variation and chromosome studies of *Calligonum mongolicum* and *C. pumilum* (Polygonaceae). Nordic Journal of Botany, 27(2): 81−85.

Song Y. 2001. Vegetation Ecology. Shanghai: East China of Normal University Press, 549–588.

Stebbins G L. 1950. Variation and Evolution in Plants. New York: Columbia University Press, 1–664.

Su Y, Zhao H. 2002. Advances in researches on soil organic carbon storages, affecting factors and its environmental effects. Journal of Desert Research, 22(3): 220–228.

Tan Y, Zhang Q, Pan B R, *et al*. 2008a. Coupling relationship between *Calligonum* L. community species diversity and soil factors in China. Arid Land Geography, 31(1): 88–96.

Tan Y, Zhang Q, Pan B R, *et al*. 2008b. Study on physical and chemical properties of soil under *Calligonum* L. communities in China. Arid Zone Research, 25(6): 835–841.

Tao L, Ren J. 2004. Analysis of morphological variations among populations of *Calligonum rubicundum*. Acta Botanica Boreali–Occidentalia Sinica, 24(10): 1906–1911.

Turesson G. 1922. The genotypical response of the plant species to the habitat. Heresitas, 3(1): 211–350.

Xu B. 1986. The significance of ecological variation in plant taxonomy and evolution. Guangxi Flora, 3(1): 201–216.

Zhang D Y, Wang H L. 2005. Preliminary study plants on the growth pattern of several clonal in desert zones of Xinjiang. Arid Zone Research, 22(2): 219–224.

Zhang Y Z. 2007. Analysis of Variance of Classification Characteristics in *Calligonum ebi–nuricum* Ivanov ex Soskov. Ph.D Thesis. Urumqi: Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences.

Zhu C Y, Ding T D. 1991. Physics of Drifting Sand. Beijing: Chinese Forestry Press, 44–51.