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Evaluation of European carrot genotypes for their nutritive characters

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ABSTRACT

Carrots are globally important vegetable crop providing a source of important nutritional compounds through natural antioxidants whilst adding flavour and texture to many diets. Among vegetables, carrot is the single major source of β-carotene providing 17% of the total vitamin A consumption. Among 32 temperate carrot inbreds, KT61-950 had maximum moisture content with 96.63%, TSS in KS-59 (16.10°Brix), while total carotenoids and lycopene in KS-38 (24.94 mg and 12.87 mg/100 g). Minerals are involved in numerous biochemical processes, and an adequate intake of essential minerals is necessary for good health. A wide range of variability in mineral content was observed in 46 European carrot inbreds. Highest potassium content was estimated in KS 31 (1777.75 ppm), magnesium (286.43 ppm) in KS 5, iron (85.99 ppm) in Acc. 399, copper (4.22 ppm) in EC 683447, manganese (21.99 ppm) in KS 37 and zinc (14.58 ppm) in KS 34.

Key words: β-carotene, carrot, lycopene, mineral content, variability.

INTRODUCTION

Vegetables are rich in health promoting phytochemicals and play an important role in alleviating malnutrition. Carrot (*Daucus carota* L.) is an important vegetable crop worldwide economically, nutritionally and as a protective food especially as a source of pro-vitamin A and β-carotene (Simon, 7). Carrot is rich in carotenoids, vitamins and mineral nutrients. Carotenoids are vital components of photosynthetic cells, where they play an important accessory role in harvesting light and transferring energy to the chlorophylls. β-carotene is the foremost anti-cancer vitamin, and the World Health Organization and Food and Agriculture Organization have declared it a vital nutritional pigment (Wang *et al.*, 9). Minerals are involved in numerous biochemical processes, and an adequate intake of essential minerals is necessary for good health. The recommended daily intake of Ca, Cu, Fe, Mg, Mn, K, Zn, P and Na are 1000, 2, 18, 400, 2, 1000, 15, 4000 and 2400 mg per day, respectively (FNB, 1). Malnutrition is a major concern for many developing countries. Iron deficiency anemia, for example, affects one-third of the world's population (Kumari *et al.*, 5). Therefore, the present investigation was undertaken to study the variation for carotenoids and minerals content in temperate carrot inbreds and identify promising inbreds for utilization in the breeding programme.

MATERIALS AND METHODS

Thirty two temperate carrot inbreds were evaluated for different quality traits and mineral nutrients at IARI, New Delhi during *rabi* seasons of 2011 and 2012. The edible part (root) was harvested at marketable stage and fresh samples were washed under running tap water followed by double-distilled water. They were drained completely, dried over blotting paper and analysed for total carotene, lycopene, total soluble solids, moisture, and dry matter contents. Total carotene and lycopene were determined by using acetone and petroleum ether as extracting solvents (Ranganna, 6). The total soluble solids were measured by hand-held refractrometer.

Field fresh carrot sample was washed and wiped with tissue paper so as to absorb the water and the fresh weight was immediately recorded. The sample was cut into small pieces and dried in hot air-oven at temperature not exceeding 70ºC, till a constant weight is attained. The sample was allowed to cool and dry weight was recorded. The moisture content was expressed in percentage. Different micronutrients were estimated from digested plant samples by using atomic absorption spectrometer (Model-Analyst 400) as per the method outlined by Jackson (4) using air-acetylene flame and particular wavelengths and lamps specific to the nutrient. The average values of three replications were used for statistical analysis. Differences between samples were tested by analysis of variance (ANOVA). P values ≤ 0.5 were considered significant.

RESULTS AND DISCUSSION

The moisture per cent varied significantly in the genotypes, being maximum (96.63%) in KT 61-950. However, EC 683447 showed the minimum value (84.03%). Most of the inbreds possessed moisture

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content in the range of 85-90% (Fig. 1). Maximum total soluble solids was observed in KS-59 (16.10°Brix), followed by EC 683447 (13.90°Brix). The TSS ranged from 6° to 16°Brix, showing a wide variation among the genotypes. The total carotenoids and lycopene were found to be highest in KS 38 (24.94 and 12.87 mg/100 g), followed by Nantes (23.87 and 11.52 mg/100 g) and KS 37 (17.05, 1097 and 8.80 mg/100 g), respectively (Fig. 2). These variations may be due to genotypic variations. Simon and Wolf (8) also reported varied performance of cultivars with regard to genotype, location and season.

The results revealed significant differences and wide variability among the 46 genotypes for phosphorus, potassium, calcium, magnesium, iron, copper, manganese and zinc content. Among the macro elements the phosphorus content ranged from 221.75-820.26 ppm, potassium 581.33-1777.75 ppm, calcium 61.90-190.78-ppm and magnesium 58.10-286.43 ppm. Highest potassium content was estimated in KS 31 (1777.75 ppm), while KS 3 recorded the highest phosphorus (820.26 ppm). In Fig. 3A, most of the inbreds observed to be above the linear trendline for potassium. Two of the inbreds DC 1 (792.97 ppm) and KT 61-950 (581.33 ppm) were very far away and below the trendline. For phosphorus, the inbreds were nearby the trendline, while some of them like KT-PL-13, KS-59, KS-26 and KS- 27 were touching the trendline, which signifies that there phosphorus content is almost the same. For magnesium, KT 61-950 (58.10 ppm) and KS-5 (286.43 ppm), which were too far from the trendline due to their extreme values. Some of the promising inbreds having more than 200 ppm magnesium are KS-1, KS-7, KS, 34, KS-35, KS-61, KS-63 *etc.* (Fig. 3B). Similarly, for calcium KS-3 (190.78 ppm), which is having maximum value is far away from the linear trend line. Among the micro-elements iron ranged from 11.56-85.99 ppm, manganese 3.86-21.99 ppm, copper 0.9-4.22 ppm and zinc 1.56-14.58 ppm. In Fig. 3C, KT 61-950 was very far and below the trend line due to very low content of iron (11.56 ppm) and Acc. 399 (85.99 ppm) above the line, which shows their magnitude if variation in their content. Since manganese content is very minimal so the inbreds hover around the linear line. Maximum

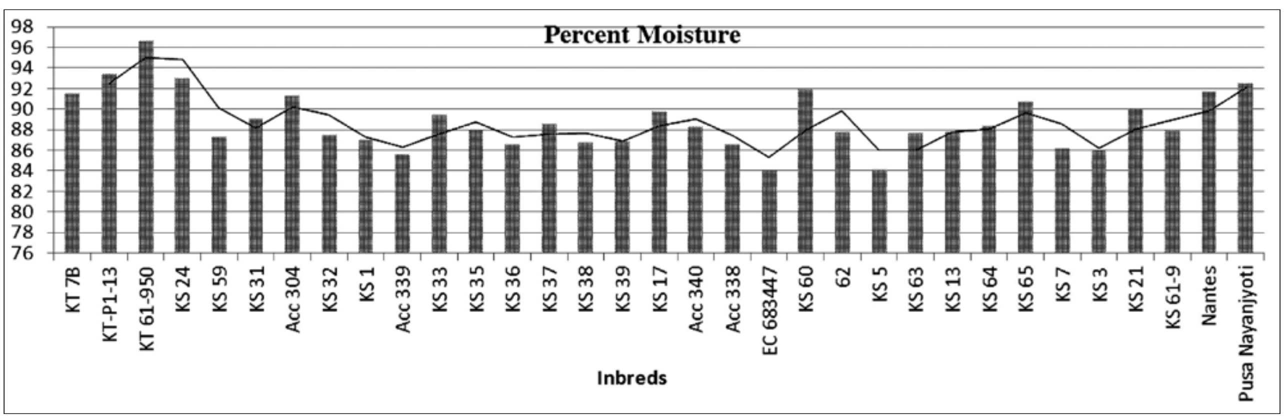


Fig. 1. Variation in the moisture content in temperate carrot genotypes.

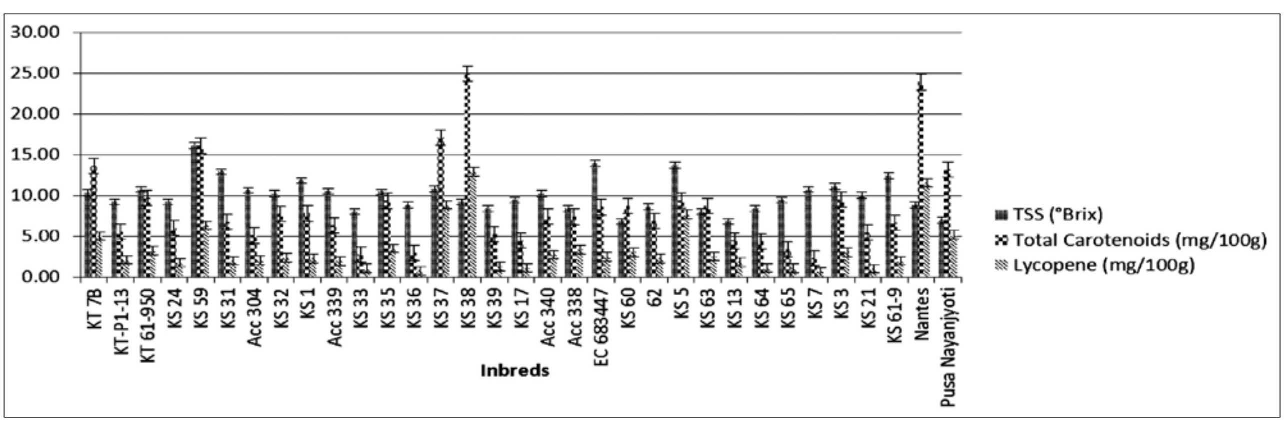
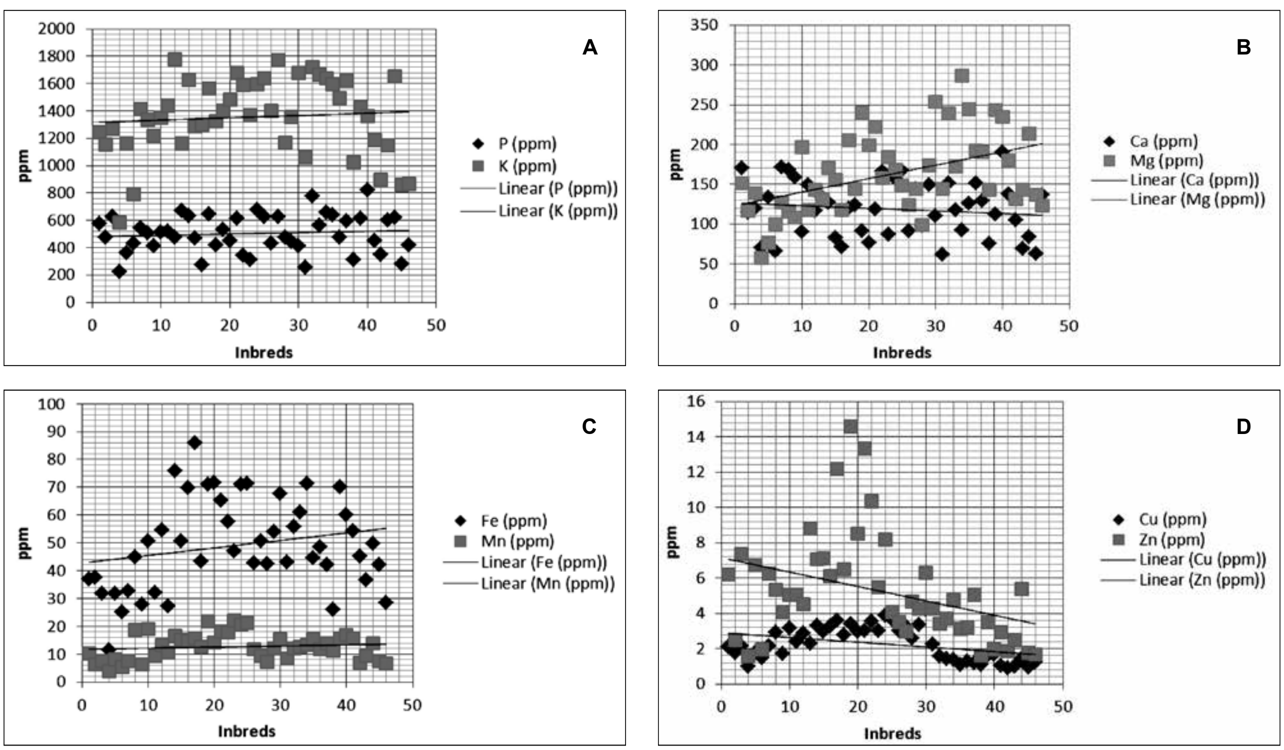


Fig. 2. Variation in the European carrot inbreds for their nutritive traits.

manganese was observed in KS 37 (21.99 ppm). From the Fig. 3D, it is observed that there is a great magnitude of variation in zinc content varying from 1.56 (KT 61-950) to 14.58 (KS-34) ppm. Some of the other promising inbreds with good zinc content (more than 10 ppm) are KS-34, KS-35, KS-36 and Acc-399, which are above the trend line. Since copper content varied from 0.9-4.22 ppm, magnitude of variation was very less and all the inbreds were hovering around the linear trend line. Maximum copper content was estimated in EC 683447 (4.22 ppm).

All the significant correlations, *viz*., phosphorus with potassium, calcium, magnesium, iron and manganese (r = 0.5830, 0.4804, 0.5323, 0.3710 and 0.3141, respectively, at P ≤ 0.05); potassium with calcium magnesium, iron, copper, manganese and zinc (r = 0.3805, 0.6186, 0.6718, 0.4812, 0.6027 and 0.3990, respectively, at P ≤ 0.05); magnesium with iron and manganese (r = 0.6717 and 0.5992, respectively, at P ≤ 0.05); iron with copper, manganese and zinc (r = 0.5479, 0.7237 and 0.4712, at P ≤ 0.05); copper with manganese and zinc (r = 0.5651 and 0.6245, at P ≤ 0.05) and manganese with zinc (r = 0.4944) were found to be positive (Table 1). Only calcium was found to be non significant with Mg, Fe, Cu, Mn and Zn elements. Such correlation analysis will facilitate selection of genotypes with improved nutritional quality, as selection for one trait leads to selection of genetically correlated traits. Hence, emphasis should be given to these traits while selecting the genotypes for higher yield in carrot (Gupta *et al*., 2).

Selection of inbreds with improved nutritional quality leads to selection of genetically correlated traits (Wricke and Weber, 10). However, correlation analysis alone cannot give a complete picture of interrelations because it considers only two minerals at a time, regardless of the interrelationship with other minerals in the set of data. Hence, PCA was carried out to understand the underlying interrelationships in the whole set of data and to select the best linear combination of minerals that explains the largest proportion of the variation in the data set. PCA revealed that the first two principal components (PCs) together governed 87.49% of the total variability (Table 2). In both the principal components, the coefficients corresponding to potassium and iron



1 = KT -7B; 2 = KT-PL-13; 3 = KT-61-922; 4 = KT-61-950; 5 = KS- 24; 6 = DC -1; 7. KS -26; 8 = KS -27; 9 = KS -50; 10 = KS- 59; 11 = KS 202; 12 = KS- 31; 13 = Acc -304; 14 = KS -32; 15 = KS- 8; 16 = KS -1; 17 = Acc -339; 18 = KS -33; 19 = KS -34; 20 = KC -1; 21 = KS -35; 22 = KS -36; 23 = KS -37; 24 = KS -38; 25 = KS- 39; 26 = KS -17; 27 = Acc -340; 28 = DC -17; 29 = Acc -338; 30 = EC -683447; 31 = KS- 40; 32 = KS -61; 33= KS -62; 34 = KS -5; 35 = KS 63; 36 = KS -13; 37 = KS 64; 38 = KS 65; 39 = KS 7; 40 = KS -3; 41= KS- 21, 42 = KS-20; 43 = KS -22; 44 = KS 61-9; 45 = Nantes; 46 = Pusa Yamdagini.

Fig. 3. Mineral content in European carrot inbreds.

Table 1. Linear correlation (r) between macro- and micro-nutrients in temperate carrot genotypes.

Macro/micro-nutrient	P	K	Ca	Mg	Fe	Cu	Mn
K	0.5830*						
Ca	0.4804*	0.3805*					
Mg	0.5323*	0.6186*	0.0630				
Fe	0.3710*	0.6718*	0.0804	0.6717*			
Cu	0.0566	0.4812*	0.1569	0.1080	0.5479*		
Mn	0.3141*	0.6027*	0.1786	0.5992*	0.7237*	0.5651*	
Zn	0.1924	0.3990*	0.0868	0.2720	0.4712*	0.6245*	0.4944*

*Significant at 5% level.

Table 2. Eigen vectors and eigen values for first two principal components (PC1 and PC2) in temperate carrot genotypes.

Eigen values of the correlation matrix				
	Eigen value	Difference	Proportion	Cumulative
1	3.99700671	2.57674131	0.4996	0.4996
2	1.42026540	0.35813697	0.1775	0.6772
3	1.06212843	0.54194085	0.1328	0.8099
4	0.52018758	0.15327138	0.0650	0.8749
5	0.36691621	0.10829734	0.0459	0.9208
6	0.25861887	0.03116927	0.0323	0.9531
7	0.22744959	0.08002238	0.0284	0.9816
8	0.14742722		0.0184	1.0000

were positive and consistent. Since, these two minerals in PC1 and PC2 accounted for more of the variation in the set of data than other minerals, they were the most appropriate to use in the preliminary grouping of the 46 temperate carrot genotypes evaluated in this study.

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