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Quality Assessment of Newly Introduced Genotypes of Beet root (*Beta vulgaris* L)

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Abstract: *Twenty five diverse genotypes of beet root procured from Institute of Plant Genetic and Crop Plant Research, Gatersleben, Germany (IPGCPR) and India, including two checks were evaluated for yield and quality characteristics. Analysis of variance showed highly significant differences among genotypes for all the characters under study. Genotype TNBR-1 gave 44.10 and 27.70 per cent more yield over check cultivars Crimson Globe and Detroit Dark Red, respectively and also performed better for other characters. Genotype TNBR-8 and BETA -340 performed better than both the checks for total soluble solids. On the basis of results obtained in the present investigations, it was concluded that TNBR-1 proved as the best genotype for yield and other quality characters.*

Keywords: *Beet root (Beta vulgaris L.), genotypes, yield quality.*

INTRODUCTION

Beet root (*Beta vulgaris* L.) is a member of the family Chenopodiaceae, commonly known as Goosefoot family. It is highly productive and believed to be native of Europe, West Asia and Africa Vavilov (10). Initially, red beets may have been used primarily as a leafy vegetable, and interest in the storage root occur later, possibly after 1500 AD. Fodder beet probably began to cultivate about 1800 AD and sugar beet apparently originated from the fodder beet population Rubatzky and Yamaguchi (7).

It is grown particularly for the enlarged hypocotyl, so called "root" which is eaten raw as salad or cooked with other vegetables and with meat. Storage roots size range from as little as 2 cm to over 15 cm in diameter. Shapes are variable and may be globe, cylindrical top like and flattened. Upper portion of root develop from hypocotyl and lower from tap root. The tap root may penetrate the soil to a depth of 10 feet Weaver and Bruner (11). The extensive root system penetrating to a great depth indicates draught resistant property of beet.

The ancient Greek used both the leaves and the roots as a vegetable. Beet root is rich in protein, carbohydrate, iron, calcium, phosphorus, vitamin C and betanine, which is important for cardiovascular health. It has also been shown to lower blood pressure and thus help to prevent cardiovascular problems. Beet root also contains a relatively high level of folic acid. Betanin obtained from the roots, is used industrially, as red food colourants to improve color and flavour of tomato paste, sauce, jam and juices. In Eastern Europe beet soup such as borscht, is a popular dish. Sometimes it is used in preparation of pickles and chutneys. Table beet is grown for its fleshy tap root and leafy types. The relative sugar beet is grown for the high sucrose contents of the roots. Sugar level of present day sugar cultivar approaches 20 per cent of the fresh weight, those of table beet about 6 per cent or less.

Beet root is a temperate crop grown for edible roots in the plains and for seeds in hills. In India, temperate climate prevails only in the hills of Himachal Pradesh, Jammu and Kashmir, Uttrakhand and Uttar Pradesh which is suitable for breeding and seed production of beet root.

It is a self-incompatible, cross pollinated crop and pollination is done by wind, although some insect pollination may occur. It is biennial in nature from seed production point of view Abegg (1). Male sterility

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is used for hybrid seed production. In the first season it forms a rosette of leaves and fleshy taproot is produced, whereas in second year one or more branched seed stalks develops from crown. The beet seed botanically is a fruit, but actually a seed ball, which contain usually two to six seeds called "glomerule" or multigerm seed. The true seeds are small kidney shaped and brown in color and which remain viable for two to six years under normal storage conditions.

In Himachal Pradesh, beet root is cultivated almost round the year like radish. During summer months, it is cultivated as off-season crop in the higher hills, brings lucerative returns to the farmers. So far, there exist few released varieties which are accepted for cultivation by the farmers. There is an urgent need to study the variability for horticultural traits in temperate type varieties, so that superior varieties/ hybrids may be developed commercial cultivation in Himachal Pradesh.

Thus, keeping in view the above need for variability study in beet root some new genotypes procured from indigenous and exotic sources have been evaluated to formulate further breeding programme. Hence, the study was carried out to estimate the extent of genetic variability in the beet root crop.

MATERIAL AND METHODS

The present investigations entitled "Studies on genetic evaluation of beet root (*Beta vulgaris* L.)" were carried out at the Experimental Farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during the *Rabi* season of 2011-12 and 2012-13. Twenty five diverse genotypes of beet root collected from different exotic and indigenous sources including two recommended varieties Crimson Globe and Detroit Dark Red as checks were used for the present investigations (Table 1). All the genotypes were planted in a Randomized Complete Block Design (RCBD) in three replications. Seeds were directly sown in the field in the month of August, during 2011-12 and 2012-13 respectively at a spacing of 30 cm x 10 cm in a raised bed of 3.0 m × 1.8 m size, accommodated 180 plants per plot. The standard cultural practices recommended in the Package of Practices for Vegetable Crops at page number 131 were followed to ensure a healthy crop stand of beet root Anonymous (3). The observations were recorded

Table 1
List of beet root genotypes studied with their sources

Sr. No.	*Genotype*	*Source*
1.	TNBR-1	TNAU, Coimbatore, Tamilnadu
2.	TNBR-2	TNAU, Coimbatore, Tamilnadu
3.	TNBR-3	TNAU, Coimbatore, Tamilnadu
4.	TNBR-4	TNAU, Coimbatore, Tamilnadu
5.	TNBR-5	TNAU, Coimbatore, Tamilnadu
6.	TNBR-6	TNAU, Coimbatore, Tamilnadu
7.	TNBR-8	TNAU, Coimbatore, Tamilnadu
8.	TNBR-9	TNAU, Coimbatore, Tamilnadu
9.	TNBR-10	TNAU, Coimbatore, Tamilnadu
10.	BETA-33	IPGCPR, Gatersleben Germany
11.	BETA-34	IPGCPR, Gatersleben Germany
12.	BETA-49	IPGCPR, Gatersleben Germany
13.	BETA-99	IPGCPR, Gatersleben Germany
14.	BETA-112	IPGCPR, Gatersleben Germany
15.	BETA-133	IPGCPR, Gatersleben Germany
16.	BETA-135	IPGCPR, Gatersleben Germany
17.	BETA-154	IPGCPR, Gatersleben Germany
18.	BETA-273	IPGCPR, Gatersleben Germany
19.	BETA-340	IPGCPR, Gatersleben Germany
20.	BETA-344	IPGCPR, Gatersleben Germany
21.	BETA-1529	IPGCPR, Gatersleben Germany
22.	BETA-2221	IPGCPR, Gatersleben Germany
23.	BETA-22291	IPGCPR, Gatersleben Germany
24.	Crimson Globe*	IARI, Regional Research Station, Katrian, Kullu
25.	Detroit Dark Red*	IARI, Regional Research Station, Katrian, Kullu

Check cultivars:
TNAU : Tamil Nadu Agriculture University
IPGCPR : Institute of Plant Genetic and Crop Plant Research, Gatersleben, Germany

from ten randomly selected plants from each plot in each replication on different characters, *viz*. yield per plot, carotenoid content, dry matter recovery, TSS and total sugars. The flesh thickness of ten randomly selected roots was calculated in millimeters with the help of digital Vernier calliper. For dry matter estimation the roots harvested in each plot were thoroughly cleaned and washed in running tap water to remove the adhered soil and then a sample of one kilogram fresh roots was drawn from each plot. These roots samples were then oven dried at 65 ± 5°C till a constant weight. The dry matter recovery was expressed in percentage. Total soluble solids, total sugars and carotenoid content were calculated as per the method suggested by Ranganna (8). All the data pertaining to root and quality were analyzed as per randomized block design. Analysis of variance as described by Gomez and Gomez (5). The treatment mean were tested at 5 per cent and/or 1 per cent level of significance.

Table 2
Mean performance of different genotypes of beet root for yield/plot and carotenoid contents

Sr. No.	*Years*	*Yield / plot (kg)*			*Carotenoid contents (µg/100g)*		
	Genotypes	*2011-12*	*2012-13*	*Mean*	*2011-12*	*2012-13*	*Mean*
1.	TNBR- 1	30.57	30.00	30.29	20.28	20.50	20.39
2.	TNBR- 2	21.40	20.88	21.14	20.02	20.08	20.05
3.	TNBR- 3	18.02	17.76	17.89	20.41	20.35	20.38
4.	TNBR- 4	20.70	20.37	20.54	20.00	20.00	20.00
5.	TNBR- 5	24.80	24.01	24.40	20.08	20.02	20.05
6.	TNBR- 6	15.91	15.84	15.88	20.36	20.25	20.31
7.	TNBR- 8	13.16	12.93	13.04	20.04	20.02	20.03
8.	TNBR -9	15.96	15.74	15.85	20.65	20.61	20.63
9.	TNBR -10	17.69	17.14	17.42	19.82	19.89	19.86
10.	BETA-33	17.53	17.22	17.38	20.02	19.92	19.97
11.	BETA-34	16.40	15.49	15.95	20.42	20.30	20.36
12.	BETA-49	15.84	15.65	15.75	19.99	19.81	19.90
13.	BETA-99	16.43	16.01	16.22	19.69	19.56	19.62
14.	BETA-112	14.86	14.31	14.58	19.51	19.43	19.47
15.	BETA-133	15.72	14.77	15.24	20.20	20.17	20.19
16.	BETA-135	14.35	13.20	13.78	20.17	20.13	20.15
17.	BETA-154	13.45	13.08	13.26	19.52	19.37	19.44
18.	BETA-273	14.44	13.74	14.09	19.37	19.46	19.42
19.	BETA-340	14.36	13.41	13.89	19.41	19.35	19.38
20.	BETA-344	13.34	12.31	12.83	19.59	19.44	19.51
21.	BETA-1529	16.64	16.50	16.57	20.45	20.03	20.24
22.	BETA-2221	17.30	16.96	17.13	20.38	20.33	20.36
23.	BETA-22291	16.89	16.47	16.68	19.96	19.86	19.91
24.	Crimson Globe	21.97	21.81	21.90	20.00	20.00	20.00
25.	Detroit Dark Red	17.18	16.68	16.93	20.54	20.46	20.50
	Mean	18.09	17.56		20.03	19.97	
		$CD_{0.05}$			$CD_{0.05}$		260.22
		Genotypes		: 2.39	Genotypes		: 0.19
		Years		: NS	Years		: 0.05
		Genotypes × Years		: NS	Genotypes × Years		: NS

RESULTS AND DISCUSSIONS

The observations recorded on yield per plot, carotenoid content, dry matter recovery, total sugars and TSS after analysis are presented in Table 2, 3 and 4 respectively. It is evident from data that significant differences among genotypes were recorded for all the characters under study. The difference between the mean values of different genotypes for yield per plot ranged from 12.83-30.29 kg/plot. It was clear from mean values of different genotypes (Table 2) that maximum yield/plot was recorded by genotype TNBR-1 (30.29 kg/plot). The minimum yield of 12.83 kg was recorded in BETA-344 and found statistically at par with TNBR-8 (13.04 kg), BETA-154 (13.26 kg), BETA-135 (13.78 kg), BETA-340 (13.89 kg) and BETA-273 (14.09 kg). The different years of study and their interactions (Genotypes x Years) exhibited non-significant effects on yield/plot. Analysis of variance showed significant differences among genotypes for carotenoid contents and it varied from 19.38-20.63 µg/100 gm (Table 2). Maximum contents of 20.63 µg/100 gm were observed in TNBR-9 which was statistically at par with cultivar Detroit Dark Red (20.50 µg/100 gm). Minimum contents were recorded in BETA-340 (19.38 µg/100 gm) followed by BETA-273 (19.42 µg/100gm), BETA-154 (19.44 µg/100 gm) and BETA-112 (19.47 µg/100 gm). Similarly significantly higher contents were also observed in 2011-2012 (50.53 µg/100 gm) in comparison to 2012-2013 (49.58 µg/100 gm). Interactions (Genotypes x Years) exhibited non-significant effects on carotenoid contents. Analysis of variance showed significant differences among the genotypes for dry matter recovery. The difference of mean values ranged from 12.79 - 19.77 per cent (Table 3). Maximum dry matter recovery (19.77%) was recorded in genotype TNBR-1 and was at par with TNBR-5 (19.11%). Minimum dry matter recovery of 12.79 per cent was obtained in BETA-344 which was

Table3
Mean performance of different genotypes of beet root for dry matter content(%) and total sugars

Sr. No.		Dry matter content (%)			Total Sugars (%)		
	Years	2011-12	2012-13	Mean	2011-12	2012-13	Mean
	Genotypes						
1.	TNBR- 1	20.18 (4.49)*	19.37 (4.40)	19.77 (4.45)	21.88 (4.68)	20.00 (4.47)	20.94 (4.58)
2.	TNBR- 2	17.46 (4.18)	17.02 (4.12)	17.24 (4.15)	21.54 (4.64)	19.51 (4.42)	20.52 (4.53)
3.	TNBR- 3	17.28 (4.16)	16.53 (4.07)	16.91 (4.11)	20.77 (4.56)	19.47 (4.41)	20.12 (4.49)
4.	TNBR- 4	17.41 (4.17)	16.79 (4.10)	17.10 (4.14)	20.84 (4.56)	19.50 (4.41)	20.17 (4.49)
5.	TNBR- 5	19.47 (4.41)	18.76 (4.33)	19.11 (4.37)	21.63 (4.65)	19.59 (4.42)	20.61 (4.54)
6.	TNBR- 6	16.40 (4.05)	15.08 (3.88)	15.74 (3.97)	20.16 (4.49)	18.30 (4.28)	19.23 (4.39)
7.	TNBR- 8	13.29 (3.65)	12.75 (3.57)	13.02 (3.61)	18.74 (4.33)	17.84 (4.22)	18.29 (4.28)
8.	TNBR -9	15.81 (3.98)	14.16 (3.76)	14.98 (3.87)	19.93 (4.46)	18.20 (4.27)	19.06 (4.37)
9.	TNBR -10	17.30 (4.16)	16.09 (4.01)	16.70 (4.09)	20.53 (4.53)	18.47 (4.30)	19.50 (4.42)
10.	BETA-33	16.22 (4.03)	15.55 (3.94)	15.89 (3.99)	20.48 (4.52)	18.36 (4.28)	19.42 (4.40)
11.	BETA-34	14.33 (3.79)	14.38 (3.79)	14.35 (3.79)	19.80 (4.45)	18.17 (4.26)	18.99(4.36)
12.	BETA-49	15.45 (3.93)	14.05 (3.75)	14.75 (3.84)	19.91 (4.46)	18.20 (4.26)	19.06(4.36)
13.	BETA-99	15.37 (3.92)	15.40 (3.92)	15.39 (3.92)	20.12 (4.48)	18.24 (4.27)	19.18 (4.38)
14.	BETA-112	14.35(3.79)	13.22 (3.63)	13.79 (3.71)	19.63 (4.43)	18.11 (4.25)	18.87(4.34
15.	BETA-133	15.02 (3.88)	13.49 (3.64)	14.26 (3.78)	19.70 (4.44)	18.15 (4.26)	18.93 (4.35)
16.	BETA-135	13.43 (3.66)	13.43 (3.66)	13.43 (3.66))	20.37 (4.51)	18.35 (4.28)	19.36 (4.40)
17.	BETA-154	13.58 (3.68)	12.17 (3.49)	12.88 (3.59)	18.83 (4.34)	17.91 (4.23)	18.37)(4.29)
18.	BETA-273	14.44 (3.80)	13.09(3.62)	13.76 (3.71)	19.58 (4.42)	17.84 (4.22)	18.71 (4.32)
19.	BETA-340	13.35 (3.65)	12.87 (3.59)	13.11 (3.62)	18.50 (4.30)	17.80 (4.22)	18.15 (4.26)
20.	BETA-344	13.24 (3.64)	12.33 (3.51)	12.79 (3.58)	18.67 (4.32)	17.82 (4.22)	18.25 (4.27)
21.	BETA-1529	15.05 (3.88)	14.29 (3.78)	14.67 (3.83)	19.61 (4.43)	18.08 (4.25)	18.85 (4.34)
22.	BETA-2221	16.63 (4.08)	15.09 (3.89)	15.86 (3.98)	19.85 (4.45)	18.20 (4.26)	19.02 (4.36)
23.	BETA-22291	16.46 (4.06)	15.04 (3.88)	15.75 (3.97)	18.74 (4.33)	18.20 (4.26)	18.47(4.30)
24.	Crimson Globe	17.24 (4.11)	16.42 (4.05)	16.83 (4.10)	20.93 (4.58)	19.43 (4.41)	20.18 (4.49)
25.	Detroit Dark Red	18.48 (4.15)	18.19 (4.26)	18.34 (4.28)	21.19 (4.61)	19.52 (4.42)	20.36 (4.51)
	Mean	15.89 (3.98)	15.02(3.87)		20.08 (4.48)	18.53 (4.30)	
		$CD_{0.05}$			$CD_{0.05}$		
		Genotypes		: 0.09	Genotypes		: 0.40
		Years		: 0.07	Years		: 0.10
		Genotypes × Years		: NS	Genotypes × Years		: NS

at par with BETA-154 (12.88%), TNBR-8 (13.02%), BETA-340 (13.11%) and BETA-135 (13.43%). The differences between different years of study were significant and higher dry matter recovery was in 2011-12 (15.89%) and lower during 2012-13 (15.02%). Interaction effects between genotypes and years were non-significant. The data recorded on total sugars revealed significant differences among the genotypes. The difference between mean values of the genotypes for this trait varied from 18.15-20.94 per cent. It is evident from the data (Table 3) that maximum value of 20.94 per cent was recorded in TNBR-1 which was at par with TNBR-5 (20.61%) whereas minimum total sugars (18.15%) were recorded in genotype BETA-340 (18.15) followed by BETA-344 (18.25%), TNBR-8 (18.29%) and BETA-22291 (18.47%). The results of different years of study depicted that maximum total sugars were observed in 2011-12 **(**20.08%) and minimum in 2012-13 (18.53%). Interactions (Genotypes x years) had no significant influence on this trait. A perusal of the data revealed significant differences among the genotypes for TSS . The difference of mean values ranged from 15.81-19.92 °B. It is evident from the Table 4 that TSS as high as 19.92 °B was observed in genotype TNBR-8. The lowest value of 15.81 °B was observed in TNBR-6. The results of different years of the study depicted that higher TSS of 19.01°B was recorded in 2011-12 as compared to 2012-13 16.63 °B). The interactions effects revealed that genotypes x years had non-significant influence on this trait. Wide range of variation for different quantitative and qualitative characters in different genotypes of wild type of beets had also been reported by Manhaley *et al*. (6), Baranski *et al.* (4) and Srivastava *et al*. (9) in garden beet, Ahmed *et al*. (2) in sugar beet, Yadav *et al.* (12) in carrot. Root yield per plot is one of

Table 4
Mean performance of different genotypes of beet root for TSS (°B)

Sr .No.		*TSS (°B)*		
	Years	*2011-12*	*2012-13*	*Mean*
	Genotypes			
1.	TNBR- 1	18.03	18.37	18.20
2.	TNBR- 2	18.40	17.41	17.90
3.	TNBR- 3	19.70	17.67	18.68
4.	TNBR- 4	18.73	17.13	17.93
5.	TNBR- 5	18.83	18.60	18.72
6.	TNBR- 6	16.59	15.03	15.81
7.	TNBR- 8	21.20	18.63	19.92
8.	TNBR -9	20.70	16.84	18.77
9.	TNBR -10	20.73	16.53	18.63
10.	BETA-33	20.03	15.16	17.60
11.	BETA-34	18.77	17.53	18.15
12.	BETA-49	19.47	17.23	18.35
13.	BETA-99	18.70	17.90	18.30
14.	BETA-112	18.87	15.36	17.12
15.	BETA-133	18.60	14.36	16.48
16.	BETA-135	19.97	15.17	17.57
17.	BETA-154	19.43	14.37	16.90
18.	BETA-273	18.70	15.47	17.08
19.	BETA-340	18.37	16.14	17.26
20.	BETA-344	19.63	17.00	18.32
21.	BETA-1529	17.30	17.37	17.33
22.	BETA-2221	18.50	17.22	17.86
23.	BETA-22291	18.50	18.03	18.27
24.	Crimson Globe	18.43	16.60	17.52
25.	Detroit Dark Red	19.27	14.67	16.97
	Mean	19.01	16.63	
		$CD_{0.05}$		
		Genotypes		: 0.55
		Years		: 0.16
		Genotypes × Years		: NS

the most desirable traits attaining highest consideration in any beet root breeding programme. Genotypes under investigation showed great variability for root yield per plot. Maximum root yield of 30.29 kg per plot was recorded in genotype TNBR-1 and gave 44.10 and 27.70 per cent more yield over check cultivars Crimson Globe and Detroit Dark Red, respectively. This cultivar also performed well for majority of other character *viz*., average root weight, carotenoid content, dry matter recovery, carotenoid content and total sugars. Genotype TNBR-1 requires further testing for its better utilization in breeding programme where as, TNBR-8 recorded higher TSS.

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