International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(4): 1662-1666

Received: 01-05-2017
Accepted: 02-06-2017

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Quality characters of diverse pumpkin (*Cucurbita moschata*) genotypes of India with special reference to vitamin A content under eastern Himalayan region

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Abstract
Utilization of genetic diversity has been considered as the most important approach for nutritional security and crop improvement. Henceforth, thirty pumpkin genotypes from different parts of India were collected and evaluated for quality characters to diversify the food basket and crop improvement under eastern Himalayan region during three consecutive years (2014-15, 2015-16 and 2016-17). The experimental findings recorded significant variation for leaf chlorophyll content (42.96-59.48, 34.28-53.79 and 29.27-46.35 SPAD values at 30, 60 and 90 DAT), dry matter (3.27-8.49 %), ascorbic acid (5.63-18.94 mg/100 g), TSS (5.61-10.62 °brix), fruit skin toughness (1871.60-4332.64 g/mm^2), fruit skin thickness (2.29-4.63 mm) and vitamin A content (943.93-5950.28 IU). All the quality characters reported significant positive association with vitamin A content signifying scope of crop improvement. The genotypes PCB-10, PCM-18, PCM-20 and PCA-23 could be promoted in eastern Himalayan region owing to its' high vitamin A (>4000 IU) content.

Keywords: ascorbic acid, fruit skin thickness, pumpkin leaf chlorophyll, tss and vitamin a

Introduction
The World Health Organization declared that the vitamin A deficiency is a significant concern in developing countries. Arlappa (2013) [2] opined that long term and sustainable food-based intervention is most appropriate for improving vitamin A status in general and in pre-school children in particular. In this connection, the daily recommended dietary allowance of vitamin A for adults (3000 IU), pregnant women (2600 IU) and children (2300 IU) might be complemented through the carotene rich vegetables like pumpkin, which would be a sustainable food-based intervention as discussed earlier. However in spite of its high vitamin A content and economic importance, the genetic potential of pumpkin has been unexplored till now (Rajan and Markose, 2013) [4]. Consequently, the present need to ameliorate vitamin A deficiency was pushing towards systematic study of vitamin A rich crops like pumpkin.
Although pumpkin (*Cucurbita moschata* Duch. ex Poir.; Cucurbitaceae; 2n = 40) was introduced from South America it was well accepted and wide spread in India due to the delicious young leaves, flowers, fruits and long storability. Moreover the kitchen gardens of North-east India were well known for diverse collection of potential species. In which continuous selection has been done for superior quality and fruit yield since time immemorial. This caused the development of ample variability in cross pollinated pumpkin.
Utilization of such genetic diversity has been considered as the most important approach for nutritional security and crop improvement. This will go forward with collection, documentation, evaluation and characterization which will build the strong primitive pace for crop improvement programme to combat the said deficiency in India. Henceforth, the widespread pumpkin genotypes from West Bengal, Meghalaya, Andhra Pradesh, Manipur, Tripura and Arunachal Pradesh were collected and evaluated to record the quality characters to diversify the food basket and crop improvement under eastern Himalayan region.

Material and Methods
The present study was carried out at Instructional farm, Uttar Banga Krishi Vishwavidyalaya, West Bengal, India for three consecutive years during November-April of 2014-15, 2015-16

and 2016-17. The experimental material was comprised of 30 pumpkin genotypes (Table 1), including local genotypes of West Bengal and other parts of the country. The experiment was laid out in a Randomized Block Design with three replications. Each bed was prepared with 6m width keeping 50 cm spacing between the beds. In each bed, pits with 30 cm width and depth were prepared on bund of the raised bed at 2 m spacing along the side of irrigation channel for ease during irrigation and seedlings were transplanted to main field at 2-4 leaf stage. All the recommended cultural practices were adopted to raise a healthy crop.

Four plants were randomly selected in each genotype from each replication and observations on quality characters were recorded as given below.

Leaf chlorophyll content was measured with the help of Chlorophyll Meter (Made of Konica Minolta Sensing, INC, Japan) with the unit of SPAD-502 at 30, 60 and 90 days after transplanting (DAT). Chlorophyll content at 90 DAT was only considered for character association studies.

Pumpkin flesh was separated without skin, sliced, weighed and subsequently dried in the hot air oven at 60 ºC for 48-72 hours. Then the final dry weight was recorded. The dry matter (%) was calculated using the formula:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of the sample (g)}}{\text{Fresh weight of the sample (g)}} \text{ x } 100$$

Ascorbic acid in pumpkin fruits was determined by titrimetric method (Ranganna, 2001) [5].

$$\text{Amount of ascorbic acid (mg/100g)} = \frac{\text{Titrate x dye factor}}{\text{Aliquot of extract taken for estimation}} \times \frac{\text{volume made up x 100}}{\text{Weight of sample taken}}$$

Table 1: List of 30 pumpkin genotypes evaluated over three years (during 2014-15, 2015-16 and 2016-17)

S. No.	Code	Name of the genotype	Source of collection
1	PCP-1	Pumpkin Collection Pundibari-1	Pundibari, Cooch Behar, West Bengal
2	PCP-2	Pumpkin Collection Pundibari-2	Pundibari, Cooch Behar, West Bengal
3	PCP-3	Pumpkin Collection Pundibari-3	Pundibari, Cooch Behar, West Bengal
4	PCP-4	Pumpkin Collection Pundibari-5	Pundibari, Cooch Behar, West Bengal
5	PCP-5	Pumpkin Collection Pundibari-6	Pundibari, Cooch Behar, West Bengal
6	PCP-6	Pumpkin Collection Pundibari-7	Pundibari, Cooch Behar, West Bengal
7	PCK-7	Pumpkin Collection Komatipalli	Komatipalli, Vizianagaram, Andhra Pradesh
8	PCG-8	Pumpkin Collection Gagan Sardar Para-1	Gagan Sardar Para, Sepahijala, Tripura
9	PCP-9	Pumpkin Collection Pasighat-1	Pasighat, East Siang, Arunachal Pradesh
10	PCB-10	Pumpkin Collection Bukkarayasamudram	Bukkarayasamudram, Ananthapur, Andhra Pradesh
11	PCM-11	Pumpkin Collection Mankar-1	Mankar, Bardhaman, West Bengal
12	PCT-12	Pumpkin Collection Thangmeiband-1	Thangmeiband, Imphal West, Manipur
13	PCT-13	Pumpkin Collection Thangmeiband-2	Thangmeiband, Imphal West, Manipur
14	PCM-14	Pumpkin Collection Meghalaya-1	Ampati-1, Meghalaya
15	PCM-15	Pumpkin Collection Meghalaya-2	Anugre, Meghalaya
16	PCM-16	Pumpkin Collection Meghalaya-3	Dakopgre, Meghalaya
17	PCM-17	Pumpkin Collection Meghalaya-4	Ampati-2, Meghalaya
18	PCM-18	Pumpkin Collection Meghalaya-5	Skanska, Meghalaya
19	PCM-19	Pumpkin Collection Meghalaya-6	Ron gram, Meghalaya
20	PCM-20	Pumpkin Collection Meghalaya-7	Baagmara, Meghalaya
21	PCB-21	Pumpkin Collection Baidyabati-1	Baidyabati, Hoogly, West Bengal
22	PCB-22	Pumpkin Collection Baidyabati-2	Baidyabati, Hoogly, West Bengal
23	PCA-23	Pumpkin Collection Alipurduar	Alipurduar, West Bengal
24	PCB-24	Pumpkin Collection Beldanga	Beldanga, Murshidabad, West Bengal
25	PCR-25	Pumpkin Collection Raiganj	Raiganj, U/Dinajpur, West Bengal
26	PCB-26	Pumpkin Collection Baidyabati-3	Baidyabati, Hoogly, West Bengal
27	PCB-27	Pumpkin Collection Baidyabati-4	Baidyabati, Hoogly, West Bengal
28	PCB-28	Pumpkin Collection Baidyabati-5	Baidyabati, Hoogly, West Bengal
29	PCB-29	Pumpkin Collection Baidyabati-6	Baidyabati, Hoogly, West Bengal
30	PCB-30	Pumpkin Collection Baidyabati-7	Baidyabati, Hoogly, West Bengal

TSS (ºbrix) was measured using Mettler Toledo RE50 refractometer based on total reflection method.

Fully mature fruit was used for the analysis of fruit skin thickness (mm) and fruit skin toughness (g/mm^2). TA.XT. Plus Texture analyzer (Stable Micro Systems Ltd, UK) with 2 mm stainless steel needle probe (code P/2N). The probe was set to penetrate fruit at a rate of 2 mm/sec for a distance of 5 mm. Fruit chip skin positioned against probe to allow penetration through skin. Distance travelled with peak force to pierce through the fruit skin was recorded as fruit skin thickness (cm) and the maximum force (g) needed to puncture the skin at which maximum load was achieved, recorded as fruit skin toughness (g/mm^2).

The vitamin A content was calculated from beta-carotene adopting procedure suggested by Davies (1976) [6] from following formula,

B-carotene (mg/100g) =

$$\frac{\text{Carotene concentration in sample from standard curve (µg/ml) x final volume x Dilution x 100}}{\text{Weight of sample(g) x 1000}}$$

B-carotene (µg/100g) = β-carotene (mg/100g) x 1000

Vitamin A (IU) $= \frac{\beta-\text{carotene (µg/100g)}}{0.6}$

The experimental findings were analyzed statistically for ANOVA and genotypic correlation using Windstar Version 9.2.

Results and Discussion

The observations recorded on various quality characters of pumpkin genotypes in three consecutive years (2014-15, 2015-16 and 2016-17) reported highly significant differences. However, the result based on the pooled analysis was only discussed hereunder.

Quality characters

The observations recorded on quality characters of pumpkin genotypes have been presented in Table 2a, Table 2b and Table 2c. The pooled results recorded significant variation in leaf chlorophyll content (42.96-59.48, 34.28-53.79 and 29.27-46.35 SPAD values at 30, 60 and 90 DAT); dry matter (3.27-8.49 %); ascorbic acid (5.63-18.94 mg/100 g); TSS (5.61-10.62 °brix); fruit skin toughness (1871.60-4332.64 g/mm^2); fruit skin thickness (2.29-4.63 mm) and vitamin A content (943.93-5950.28 IU) with the mean values of 50.69, 45.10, 38.57 (SPAD values at 30, 60 and 90 DAT); 4.95 (%);(11.15 mg/100 g); 6.91 (°brix); 3217.97 (g/mm^2); 3.36 (mm) and 3043.19 (IU), respectively.

Table 2a: Quality characters of pumpkin genotypes over three years (during 2014-15, 2015-16 and 2016-17)

Genotypes	Leaf chlorophyll at 30 DAP				Leaf chlorophyll at 60 DAP				Leaf chlorophyll at 90 DAP				Dry matter (%)			
	Y1	Y2	Y3	Pooled	Y1	Y2	Y3	Pooled	Y1	Y2	Y3	Pooled	Y1	Y2	Y3	Pooled
PCP-1	58.37	51.26	55.05	54.89	54.99	38.33	51.87	48.40	46.65	35.07	44.00	41.91	3.65	5.80	3.44	4.30
PCP-2	48.91	51.59	46.13	48.88	46.09	44.63	43.47	44.73	39.30	41.37	37.07	39.25	4.29	4.46	4.05	4.27
PCP-3	50.53	56.27	47.66	51.48	47.61	35.77	44.90	42.76	42.48	32.50	40.07	38.35	3.33	6.83	3.14	4.44
PCP-4	56.53	60.30	53.32	56.72	53.26	36.10	50.23	46.53	48.31	32.84	45.57	42.24	4.21	4.77	3.97	4.32
PCP-5	49.29	53.10	46.49	49.63	46.44	35.43	43.80	41.89	37.00	32.17	34.90	34.69	3.60	5.14	3.40	4.05
PCP-6	49.33	57.13	46.52	50.99	46.47	36.67	43.83	42.32	40.93	33.40	38.60	37.64	3.14	3.72	2.96	3.27
PCK-7	61.97	52.31	58.45	57.57	58.38	34.87	55.07	49.44	45.06	31.60	42.50	39.72	5.92	5.91	5.58	5.80
PCG-8	48.50	58.50	45.75	50.92	45.70	42.17	43.10	43.65	34.39	38.90	32.43	35.24	7.26	4.24	6.85	6.12
PCP-9	43.78	52.99	41.29	46.02	41.24	38.13	38.90	39.43	39.05	34.87	36.83	36.92	3.34	3.56	3.15	3.35
PCB-10	48.58	50.87	45.82	48.42	45.77	33.27	43.17	40.73	39.05	30.00	36.83	35.30	4.48	4.40	4.22	4.37
PCM-11	51.50	54.00	48.58	51.36	48.52	37.07	45.77	43.79	39.26	33.80	37.03	36.70	4.34	4.16	4.09	4.19
PCT-12	48.24	53.28	45.50	49.01	45.45	36.87	42.87	41.73	30.01	33.60	28.30	30.64	4.21	4.61	3.97	4.26
PCT-13	47.22	45.07	44.53	45.61	34.50	35.80	32.54	34.28	32.31	32.54	30.47	31.77	4.88	4.90	4.61	4.80
PCM-14	51.09	65.38	48.19	54.88	48.14	54.68	45.40	49.40	35.66	50.41	33.63	39.90	4.60	4.90	4.34	4.61
PCM-15	45.43	59.04	42.84	49.10	42.80	48.34	40.37	43.84	32.09	44.08	30.27	35.48	6.34	4.59	5.98	5.64
PCM-16	56.60	68.44	53.39	59.48	53.33	57.74	50.30	53.79	44.04	53.47	41.53	46.35	5.63	3.99	5.31	4.98
PCM-17	46.55	62.64	43.91	51.03	43.86	51.94	41.37	45.72	35.02	47.68	33.03	38.58	4.30	5.32	4.05	4.56
PCM-18	47.68	62.50	44.97	51.71	44.92	51.80	42.37	46.36	36.83	47.53	34.73	39.70	7.58	7.48	7.15	7.40
PCM-19	42.80	60.77	40.37	47.98	40.33	50.07	38.03	42.81	39.12	45.80	36.90	40.61	9.48	6.21	8.94	8.21
PCM-20	47.34	62.39	44.65	51.46	44.60	51.69	42.07	46.12	42.80	47.42	40.37	43.53	8.75	4.36	8.25	7.12
PCB-21	44.30	42.80	41.78	42.96	41.74	40.33	39.37	40.48	30.18	29.16	28.47	29.27	3.72	3.60	3.51	3.61
PCB-22	54.13	52.29	51.05	52.49	51.00	49.27	48.10	49.46	38.35	37.05	36.17	37.19	4.69	4.53	4.42	4.55
PCA-23	53.19	51.39	50.17	51.58	50.11	48.42	47.27	48.60	40.71	39.33	38.40	39.48	8.76	8.46	8.26	8.49
PCB-24	52.25	50.48	49.28	50.67	49.23	47.56	46.43	47.74	44.11	42.61	41.60	42.77	5.16	4.99	4.87	5.01
PCR-25	56.83	54.90	53.60	55.11	53.54	51.73	50.50	51.92	43.79	42.31	41.30	42.46	5.28	5.10	4.98	5.12
PCB-26	45.58	44.03	42.99	44.20	42.94	41.49	40.50	41.64	41.17	39.78	38.83	39.93	4.21	4.07	3.97	4.08
PCB-27	55.89	54.00	52.71	54.20	52.66	50.88	49.67	51.07	41.00	39.61	38.67	39.76	4.74	4.58	4.47	4.60
PCB-28	51.20	49.47	48.29	49.65	48.24	46.61	45.50	46.78	41.28	39.88	38.93	40.03	3.75	3.62	3.54	3.64
PCB-29	44.94	43.42	42.38	43.58	42.34	40.91	39.93	41.06	41.60	40.19	39.23	40.34	4.44	4.29	4.19	4.31
PCB-30	50.79	49.07	47.90	49.25	47.85	46.23	45.13	46.41	42.59	41.14	40.17	41.30	5.32	5.14	5.01	5.16
Mean	50.31	54.32	47.45	50.69	47.07	43.83	44.39	45.10	39.47	39.00	37.23	38.57	5.11	4.92	4.82	4.95
S.Em (±)	1.83	1.48	1.72	1.42	1.70	1.31	1.60	1.56	1.60	1.24	1.51	1.46	0.37	0.37	0.35	0.28
CD(P=0.05)	5.17	4.19	4.88	4.02	4.80	3.70	4.53	4.41	4.52	3.50	4.27	4.14	1.05	1.04	0.99	0.80
Minimum	42.80	42.80	40.37	42.96	34.50	33.27	32.54	34.28	30.01	29.16	28.30	29.27	3.14	3.56	2.96	3.27
Maximum	61.97	68.44	58.45	59.48	58.38	57.74	55.07	53.79	48.31	53.47	45.57	46.35	9.48	8.46	8.94	8.49

Y 1: 2014-15, Y2: 2015-16, Y3: 2016-17

Table 2b: Quality characters of pumpkin genotypes over three years (during2014-15, 2015-16 and 2016-17)

Genotypes	Ascorbic acid (mg/100g)				TSS (ºBrix)				Fruit skin toughness (g/mm^2)				Fruit skin thickness (mm)			
	Y1	Y2	Y3	Pooled	Y1	Y2	Y3	Pooled	Y1	Y2	Y3	Pooled	Y1	Y2	Y3	Pooled
PCP-1	9.69	17.73	9.51	12.31	6.13	7.08	5.78	6.33	2795.30	1918.17	2636.43	2449.97	2.47	2.11	2.39	2.33
PCP-2	7.71	9.61	7.54	8.28	6.05	6.73	5.71	6.17	3503.91	2749.87	3304.77	3186.18	4.65	2.44	4.32	3.80
PCP-3	10.54	13.38	10.34	11.42	5.95	10.07	5.62	7.21	3367.84	2773.17	3176.43	3105.81	3.32	2.34	3.13	2.93
PCP-4	7.05	13.31	6.92	9.09	6.24	5.97	5.88	6.03	1970.81	1785.20	1858.80	1871.60	4.46	2.00	4.21	3.56
PCP-5	11.69	13.02	11.43	12.05	6.75	4.95	6.37	6.02	3071.47	1752.77	2896.90	2573.71	3.08	3.13	2.91	3.04
PCP-6	8.46	13.77	8.31	10.18	6.06	9.97	5.72	7.25	3036.87	3405.90	3807.43	3416.73	3.47	2.08	3.27	2.94
PCK-7	9.62	20.67	9.43	13.24	6.11	9.72	5.77	7.20	3776.73	4004.32	4867.73	4216.26	3.53	4.01	3.01	3.52
PCG-8	10.15	16.97	9.94	12.35	5.78	5.65	5.45	5.63	3982.97	3165.63	3756.60	3635.07	4.44	2.99	4.19	3.87

PCP-9	10.23	14.60	9.99	11.61	6.49	8.85	6.12	7.15	2872.35	3030.20	3009.10	2970.55	2.81	2.41	2.65	2.62
PCB-10	10.36	36.25	10.13	18.91	10.53	11.38	9.93	10.62	3277.58	3850.70	3091.30	3406.53	2.29	2.87	2.16	2.44
PCM-11	9.17	9.05	8.78	9.00	5.94	6.40	5.60	5.98	3298.04	3118.64	3110.60	3175.76	3.01	2.58	2.85	2.81
PCT-12	10.41	18.24	10.15	12.93	6.47	10.08	6.10	7.55	3131.16	3607.07	2953.20	3230.47	2.76	3.62	2.61	3.00
PCT-13	10.08	26.30	9.87	15.42	6.40	8.30	6.03	6.91	4384.81	4477.50	4135.60	4332.64	3.92	4.03	3.70	3.88
PCM-14	13.92	19.33	13.61	15.62	6.06	6.88	5.72	6.22	4071.73	3917.43	4500.53	4163.23	3.87	3.30	3.66	3.61
PCM-15	8.86	11.55	8.67	9.69	6.27	5.97	5.92	6.05	3344.87	3719.23	3154.77	3406.29	4.15	3.97	3.60	3.91
PCM-16	8.38	14.63	8.21	10.41	7.58	10.07	7.15	8.27	3234.82	3489.30	3050.97	3258.36	2.94	2.92	2.71	2.85
PCM-17	12.39	11.36	12.10	11.95	5.44	9.18	5.13	6.59	2899.81	3778.60	2835.00	3171.14	4.25	4.72	4.08	4.35
PCM-18	12.14	18.19	11.88	14.07	8.00	11.55	7.55	9.03	3643.67	2950.67	3863.23	3485.86	3.72	3.96	3.51	3.73
PCM-19	9.90	16.21	9.78	11.96	6.79	9.37	6.40	7.52	2707.44	3965.23	2553.57	3075.41	3.91	4.58	3.69	4.06
PCM-20	15.61	18.76	15.26	16.54	6.89	6.16	6.50	6.52	3415.70	3621.53	4402.23	3813.15	4.13	4.22	3.90	4.08
PCB-21	5.57	6.14	5.46	5.72	5.81	6.35	5.48	5.88	2911.97	3087.98	2746.47	2915.47	3.21	3.40	3.02	3.21
PCB-22	7.18	7.90	7.02	7.37	5.99	8.85	5.65	6.83	3358.80	3561.81	3167.90	3362.84	3.36	3.56	3.17	3.36
PCA-23	18.47	20.29	18.05	18.94	8.34	7.52	7.87	7.91	2764.38	2931.47	2607.27	2767.70	3.05	3.23	2.88	3.05
PCB-24	6.22	6.88	6.12	6.41	7.09	7.36	6.68	7.05	2994.35	3175.34	2824.17	2997.95	3.89	4.12	3.67	3.89
PCR-25	9.84	10.84	9.64	10.11	6.95	7.10	6.55	6.87	3275.81	3473.81	3089.63	3279.75	3.93	4.17	3.71	3.93
PCB-26	7.15	7.94	7.06	7.38	6.70	6.15	6.32	6.39	2975.16	3154.99	2806.07	2978.74	3.33	3.60	3.21	3.38
PCB-27	5.49	6.04	5.37	5.63	5.80	5.57	5.47	5.61	3635.66	3855.42	3429.03	3640.04	3.04	3.22	2.87	3.04
PCB-28	8.69	9.71	8.64	9.01	5.25	9.61	4.95	6.60	2505.96	2657.43	2363.53	2508.97	2.59	2.75	2.45	2.60
PCB-29	6.63	7.31	6.50	6.82	9.07	7.33	8.55	8.31	3238.97	3034.74	3454.88	3242.86	2.29	2.43	2.16	2.29
PCB-30	9.84	10.85	9.65	10.11	6.91	3.72	6.52	5.72	2896.45	3071.52	2731.83	2899.94	4.62	4.90	4.36	4.63
Mean	9.71	14.23	9.51	11.15	6.66	7.80	6.28	6.91	3211.51	3236.19	3206.20	3217.97	3.48	3.32	3.27	3.36
S.Em (±)	0.73	1.10	0.69	1.07	0.53	0.53	0.50	0.42	257.44	225.54	242.81	170.52	0.30	0.34	0.28	0.20
CD(P=0.05)	2.07	3.11	1.96	3.02	1.50	1.49	1.42	1.18	728.77	638.48	687.35	475.12	0.84	0.95	0.79	0.56
Minimum	5.49	6.04	5.37	5.63	5.25	3.72	4.95	5.61	1970.81	1752.77	1858.80	1871.60	2.29	2.00	2.16	2.29
Maximum	18.47	36.25	18.05	18.94	10.53	11.55	9.93	10.62	4384.81	4477.50	4867.73	4332.64	4.65	4.90	4.36	4.63

Y 1: 2014-15, Y2: 2015-16, Y3: 2016-17

Table 2c: Quality characters of pumpkin genotypes over three years (during 2014-15, 2015-16 and 2016-17)

Vitamin A (IU)				
Genotype	**Y1**	**Y2**	**Y3**	**Pooled**
PCP-1	3426.77	3861.11	3232.01	3506.63
PCP-2	3804.91	4400.00	3588.66	3931.19
PCP-3	1482.84	1100.00	1398.56	1327.13
PCP-4	3586.72	4088.89	3382.87	3686.16
PCP-5	2860.08	3055.56	2697.53	2871.05
PCP-6	2894.43	3105.56	2729.92	2909.97
PCK-7	3079.65	3366.67	2904.62	3116.98
PCG-8	3606.78	4122.22	3401.79	3710.27
PCP-9	1171.34	516.67	1143.79	943.93
PCB-10	5904.32	5568.75	6377.78	5950.28
PCM-11	1985.08	1816.67	1872.26	1891.34
PCT-12	2437.71	2461.11	2299.16	2399.33
PCT-13	3245.80	3605.56	3061.32	3304.23
PCM-14	3282.37	3661.11	3095.82	3346.44
PCM-15	2442.13	2461.11	2303.33	2402.19
PCM-16	3179.09	3511.11	2998.41	3229.54
PCM-17	2282.94	2238.89	2153.19	2225.01
PCM-18	5050.54	4763.50	6166.67	5326.90
PCM-19	3784.94	3569.83	4372.22	3909.00
PCM-20	4704.54	4437.16	5677.78	4939.83
PCB-21	1281.65	816.67	1208.81	1102.37
PCB-22	2447.08	2472.22	2308.00	2409.10
PCA-23	4386.78	4137.46	5227.78	4584.00
PCB-24	3640.52	3433.62	4161.11	3745.08
PCR-25	1893.34	1688.89	1785.74	1789.32
PCB-26	3356.68	3761.11	3165.90	3427.90
PCB-27	3019.61	3284.62	2847.99	3050.74
PCB-28	2244.74	2185.14	2117.16	2182.35
PCB-29	2992.84	2246.64	2822.74	2687.41
PCB-30	1537.76	1181.98	1450.36	1390.04
Mean	3033.80	3030.66	3065.11	3043.19
S. Em (±)	213.47	307.91	193.09	112.21
CD(P=0.05)	604.31	871.64	546.62	317.64
Minimum	1171.34	516.67	1143.79	943.93
Maximum	5904.32	5568.75	6377.78	5950.28

Y 1: 2014-15, Y2: 2015-16, Y3: 2016-17

Leaf chlorophyll content have shown decreasing trend with commencement of duration of the crop. The genotype PCM-16 (59.48, 53.79 and 46.35 SPAD values) was recorded maximum chlorophyll content at 30, 60 and 90 DAT, respectively. However, PCK-21 (42.96 and 29.27 SPAD value at 30 and 90 DAT, respectively) and PCT-13 (34.28 SPAD value at 60 DAT) recorded lowest chlorophyll content among the pumpkin genotypes. Variability for chlorophyll content was in conformity with the experimental findings of Swiader and Moore (2002) [7] in pumpkin genotypes.

Dry matter content was important character which contributes for long storability of pumpkin. Maximum dry matter content (8.49%) was recorded in PCA-23 while lowest was recorded in PCP-6 (3.27%).

Maximum ascorbic acid content (18.94 mg/100 g) and TSS (10.62 °brix) was recorded in PCA-23 and PCB-10 whereas the genotype PCB-27 registered lowest ascorbic acid content (5.63 mg/100 g) and TSS (5.61 °brix). TSS content was a noticeable proportion towards sweetness of pumpkin fruits found to be superior in the present study with wide variation. Variability in ascorbic acid content and TSS was in conformity with the findings of Zinash *et al.* (2013) [8] in pumpkin.

Fruit skin toughness and fruit skin thickness at maturity were important parameters which contribute for long storability of pumpkin. The characters have shown diverse results among the pumpkin genotypes. Maximum fruit skin toughness (4332.64 g/mm^2) and fruit skin thickness (4.63 mm) was recorded in PCT-13 and PCB-30 while lowest was recorded in PCP-4 (1871.60 g/mm^2) and PCB-29 (2.29 mm), respectively. The findings were in accordance Gazmer *et al.* (2015) [9] in pumpkin genotypes.

The highest vitamin A content of pumpkin genotypes was recorded in PCB-10 (5950.28 IU) whereas the genotype PCP-9 registered lowest vitamin A content (943.93 IU). The other genotypes PCM-18, PCM-20 and PCB-22 also recorded higher amount of vitamin A (>4000 IU). Vitamin A is a vital nutrient, helps to overcome night blindness. Such a precious vitamin A found to be present in greater amounts under study with wide variation in similarity to the Norshazila *et al.* (2014) [10] in pumpkin genotypes.

Genotypic correlation

Genotypic correlation coefficients of quality characters of pumpkin genotypes for pooled data of 2014-15, 2015-16 and 2016-17 have been presented in Table 3.

Table 3: Genotypic correlation coefficient among quality characters of pumpkin genotypes

Characters	Dry matter	Vitamin C	TSS	Fruit skin toughness	Fruit skin thickness	Vitamin A
Chlorophyll	0.949**	0.959**	0.978**	0.933**	0.898**	0.871**
Dry matter		0.963**	0.969**	0.977**	0.909**	0.854**
Vitamin C			0.942**	0.936**	0.898**	0.841**
TSS				0.956**	0.904**	0.877**
Fruit skin toughness					0.916**	0.861**
Fruit skin thickness						0.824**

Here, ** indicates, 1% level of significance at genotypic level

The quality characters namely, chlorophyll (0.871), dry matter (0.854), vitamin C (0.841), TSS (0.877), fruit skin toughness (0.861), fruit skin thickness (0.824) recorded significant positive association with vitamin A content. The present results indicating that improvement in any of these quality characters will enhance the vitamin A content of pumpkin fruits. In similar manner all the quality characters revealed significant positive association among themselves which was a good sign for improvement of quality for pumpkin crop improvement.

Conclusion

The diverse pumpkin genotypes collected from various parts of India recorded wide range of variation for quality characters. Among the genotypes PCB-10, PCM-18, PCM-20 and PCA-23 having higher amount of vitamin A (>4000 IU) could be promoted for cultivation to meet daily vitamin A intake requirement in eastern Himalayan region. Besides, significant positive correlation reported by different quality characters emphasizing the scope for crop improvement.

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