Introduction, Characterisation and Evaluation of Husk Tomato (*Physalis ixocarpa* Brot.) Genotypes under Temperate Climate

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The performance of 10 husk tomato genotypes under temperate conditions was observed during 2010-12. The result revealed significant variation for all the morphological, growth, fruiting and yield attributes in various genotypes. Maximum number of basal shoots was recorded in genotype EC467440 (7.0), whereas, number of prickles/shoot were recorded maximum (8.33) in EC467449. Maximum size of fully developed leaf (147.00 mm), plant height (168.33 cm) and maximum time taken for bud burst (29.33 days) was recorded in EC467459, whereas, maximum time taken from bud burst to flowering was found in EC467449 (37.67 days). Duration of fruit bloom was recorded maximum in EC467459 and EC467440 (66.0 days in each). Maximum days taken for maturity (75.0 days), maximum number of fruit/plant (260.67), maximum fruit weight (37.67 g), highest fruit husk ratio (1.21), maximum yield/plant (9.69 g) and maximum fruit firmness (RI) (44.10) were recorded in EC467459. Total soluble solid content ranged from 6.50-11.50 ˚B and highest value was recorded in EC467440 (11.50° B). The value of juice percentage of fruits ranged was recorded maximum (3.49%) in EC467459. The titrable acid content in fruits was estimated the lowest (0.36%) in EC467445. Ascorbic acid content was estimated maximum in EC467459 (24.27mg/100g). The maximum 'L' value indicating brightness was found in EC467439 (64.15), whereas 'a' value indicating redness was recorded highest in EC467435 (-2.44) and 'b' value indicating yellowness was observed maximum in EC467440 (35.50). Study reveals that genotypes EC467459, 467455, 467440, 467435, 467439, 467446 and 467450 can be used as elite selections for the temperate regions. However, further studies are required for development of complete package of practices for further commercial cultivation.

Key Words: Ecosystem, Genotypes, Growth, Husk tomato, Quality, Yield

Introduction

Introduction and adaptations of new crops contribute to an increase in diversity of agriculture systems offering new alternatives to farmers and markets, with crops that may have a high value and for which generally there is no over production (Prophens *et al.,* 2004). Therefore, new crops can result in an increase income for farmers, contribute to a more environment friendly agriculture, and reduce the risk of crop failure and also increases botanical knowledge. There are many new crops for tropical and subtropical region that can present desirable attributes to be introduced as new crops in temperate climates. Husk tomato (*Physalis ixocarpa* Brot.), also known as tomatillo, is an important herbaceous crop of family Solanaceae, grown for its edible fruits. It is usually cultivated as short cycle (4-5 months) annual crop, however, grows as perennial in absence of frost. Husk tomato is native to Mexico where many types and some named varieties are cultivated, with variability in berry size, colour and flavour (Heiser, 1975; Dremann, 1985; Hernando and Leon, 1994). In its region of origin it is adapted to a wide altitudal range (from sea level to 3200m) including erolytic and warm areas with an intense solar radiation to humid and cloudy environment (Nuez *et al.,* 1999). Husk tomatoes are bushy and spreading plants that may grow to a height of 90-120 cm with a similar spread. Plants are indeterminate; they keep flowering and bearing fruits until killed by frost. The plant is usually sprawling and needs support. Fruits of husk tomato are small 1-4.5 cm diameter; green round berry at maturing contains many tiny seeds (Chattopadhya, 1996). At maturity the fruits are yellowish-green, smooth and sticky. Plant can successfully set fruit if the minimum temperature is above 5°C (Person *et al*., 1989., Prophens and Nuez, 1994). Fruits are firmer than tomatoes and their flavour is similar to tangy lemon. The tomatillo fruit is surrounded by an inedible paper like husk formed from the calyx. The fruits are considered ready to harvest when they have achieved maximum size, forming the husk or calyx (Saray-Meza and Loya-Ramirez, 1974), but fruits from different stages of development can be mixed and marketed. The fruits can be eaten raw, as a dessert, and appetizer or used as

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dish decorator. It is rich in vitamin A, B, B_2, C and polyphenols (Gonzalez-Mendoza *et al*., 2010; Brazanti and Monaresi 1980; Sarangi *et al.,* 1989). Its wide range of adaptation and versatile use as table purpose and processing form and increasing demand in exotic fruit market gives good prospects for the expansion of husk tomato as a new cash crop in temperate region. Keeping its importance and scope for commercial production in consideration, ten genotypes collected from different agro-zones and NBPGR, Regional Station, Shimla were evaluated for their adaptation under temperate region grown in summer season. Further genetic differences in yield and fruit quality characters among accessions from different regions (Prophens and Nuez, 1994) can be exploited for husk tomato breeding.

Materials and Methods

The experiment was taken at experimental farm of Central Institute of Temperate Horticulture, Srinagar, (J&K), during summer months (May-September 2010-11 and 2011-12). Plants from nursery were transplanted during first week of May at a spacing of 30 x 30 cm and no training and pruning was done. The experiment was laid out in Randomized Block Design with three replications. Morphological characters, flowering and fruiting parameters of the plants were periodically recorded. Data on fruit length, diameter, firmness, husk fruit ratio, juice were recorded at appropriate maturity of fruits. Total soluble solids were recorded using digital refractometer. Acidity and ascorbic acid were determined by the method of AOAC (1990). Fruit firmness was measured using HP qualities digital firmness tester model no. 63776. Colour values for L (brightness), a (redness) and b (yellowness) were recorded using hunter lab refractometer model no. 45/0, serial no. CEEZ 0285, Colourflex-Ez. Statistical analysis was performed as per Panse and Sukhatme (1985). Soil status of experimental site and climatic parameters during the cropping season are given in table 1 and 2.

Table 1. Monthly average weather data for the year 2010-12

Month	Rain (mm)	Temperature ^oC		Humidity(%)
		Max	Min	
May	20.0	21.92	9.82	59.32
June	34.9	25.17	10.78	61.10
July	31.4	28.56	16.42	59.10
August	57.0	28.52	17.63	62.29
September	53.2	27.20	12.15	56.78
October	27.9	23.77	5.50	61.97

Table 2. Initial soil properties of the experimental soil

Soil properties	Inceptisol
pH	7.1
EC (ds m^{-1})	0.48
OC (%)	0.71
Available Nitrogen (kg ha^{-1})	420.0
Available phosphorus (kg ha^{-1})	28.2
Available Potassium (kg ha^{-1})	346.0
Zinc (kg ha^{-1})	1.2
Iron (kg ha^{-1})	5.7
Copper (kg ha^{-1})	0.8
Manganese (kg ha^{-1})	6.8

pH (1:2.5), EC (1:2.5), electrical conductivity (dS m^{-1})

Results and Discussion

Morphological Characters

These genotypes showed significant variation for morphological characteristics (Table 3). Maximum number of basal shoots was recorded in EC467440 (7.00), followed by EC467459 (7.0), 467445, while it was minimum in EC467449 (2.67). Maximum number of prickles/shoot (8.33) was recorded in EC467449, followed by EC467450 (7.33), while it was minimum in EC467459 (4.00). Maximum number of single (7.67), double (5.00) and triple prickles (3.00)/shoot were recorded in EC467449. The maximum number of points of attachment of prickles was found in EC467450 and EC467455(8.67 in each), while as minimum (4.67) in EC467435. The number of bristles on upper third of shoots was found maximum in EC467449 (9.0) followed by EC467449 and EC467455 (8.0 in each), while it was found minimum in EC467435 (5.0). Fully developed leaf size was recorded in EC467459 (147.0mm) followed by EC467439 (119.51mm), it was found minimum in EC467449 (65.0mm). Maximum plant height was recorded in EC467459 (168.33cm) followed by 126.33cm in EC-467449, while it was recorded minimum in EC467446 (70.33cm). Similar results showing variation in growth characteristics like number and size of the nodes on first bifurcation of the plant; size and number of teeth/leaf, branching of *Physalis ixocarpa* has been reported by Hernando and Leon (1994), which is possibly because of their self incompatibility. Variation in growth and yield attributes in *P. pereviana* cultivars under temperate conditions were also reported by Singh *et al.* (2011).

Flowering and Fruiting Characters

The data values for flowering and fruiting characteristics of husk tomato varied significantly (Table 4). Maximum time taken to bud burst was recorded in EC467459 (29.33 days) followed by 29.00 days in EC467455, while it was minimum in EC467435 and 467446 (21.00 days each). Maximum time taken for bud burst to flowering was found 37.67 days in EC467449 followed by 36.6 days in EC467450, while minimum was recorded in EC467435 (28.67 days). The predominant number of flowers was recorded maximum (26.67) in EC467455 followed by 26.67 in EC467455, while it was recorded minimum (20.00) in EC467435. The fruit length was recorded maximum in EC467435 (35.10 mm) and minimum was recorded in EC467446 (22.71 mm), while as fruit breadth was recorded maximum in EC467459 (38.49 mm) and minimum in EC467447 (25.62 mm). The fruit bloom character was recorded maximum in EC467446 and EC467440 (66.00 in each) followed by EC467459 (62.67) while minimum fruit bloom was recorded in EC467449 (46.00). Fruit elongation of base was recorded maximum in EC467435 (29.67 mm) followed by 29.16 mm in EC467459, and minimum was recorded in EC467446 (18.38mm). The length of fruit peduncle was recorded maximum in EC467440 (17.19 mm), however minimum length of fruit peduncle was recorded in EC467449 (12.98 mm). Number of fruits/plant was found maximum in EC467459 (260.67) followed

Table 3. Morphological characteristics of husk tomato genotypes

Genotype	No. of basal shoots	No. of prickle/ shoot	No. of single prickles/ shoot	No. of double prickles/ shoots	No. of triple prickles / shoots	No. of points of attachments of prickles	No. of bristles on upper third of shoots	Size of fully developed leaf (mm)	Plant height (cm)
EC467435	3.33	4.33	1.33	2.67	0.33	4.67	5.00	119.51	96.67
EC467439	4.33	5.33	1.33	4.00	1.67	7.00	6.67	93.00	99.33
EC467440	7.00	5.00	4.67	4.00	0.33	6.00	7.67	102.67	118.67
EC467445	5.33	6.33	3.00	3.00	2.00	5.33	5.67	66.33	92.00
EC467446	4.33	5.00	3.67	3.67	0.33	6.00	5.67	90.00	70.33
EC467447	3.33	6.67	5.00	2.67	2.00	8.00	8.00	103.33	110.00
EC467449	2.67	8.33	7.67	5.00	3.00	8.00	9.00	65.00	126.33
EC467450	4.00	7.33	6.00	3.00	0.33	8.67	7.33	94.67	105.00
EC467455	5.00	6.33	5.00	4.33	2.00	8.67	8.00	94.33	114.33
EC467459	6.33	4.00	3.33	3.00	0.67	7.67	6.67	147.00	168.33
CD at 5%	0.90	1.02	1.15	1.29	1.19	1.32	1.07	4.21	2.38
SEm	0.30	0.34	0.38	0.43	0.40	0.44	0.36	1.41	0.80

Table 4. Flowering and fruiting characters of husk tomato genotypes

Genotype	Time taken to bud burst (days)	Time taken to flowering (days)	Predominant no. of flowers	Fruit Size length (mm)	Fruit breadth (mm)	Fruit bloom (days)	Fruit elongation of base. (mm)	Length of fruit peduncle (mm)	No. of fruits/ plant	Days taken for maturity	Yield / plant (kg)
EC467435	21.00	28.67	20.00	35.10	34.56	60.00	29.67	16.74	199.67	70.00	5.42
EC467439	22.67	30.67	25.33	29.23	36.25	63.67	28.67	16.16	204.33	74.67	5.41
EC467440	24.33	32.67	25.67	31.69	37.38	66.00	24.63	17.19	230.00	71.67	6.44
EC467445	23.33	34.67	23.67	37.28	33.89	54.00	29.13	15.57	200.00	64.67	4.45
EC467446	21.00	34.33	20.67	22.71	27.32	66.00	18.38	14.52	187.00	74.67	4.62
EC467447	26.33	35.67	25.67	24.19	25.62	48.33	21.65	15.19	207.67	60.00	4.97
EC467449	28.33	37.67	23.33	28.30	33.44	46.00	23.50	12.98	183.33	60.00	3.52
EC467450	27.00	36.67	24.33	24.23	27.51	59.00	20.06	16.90	204.00	73.00	5.40
EC467455	29.00	36.00	26.67	25.45	31.33	65.00	26.23	15.52	240.33	70.00	6.88
EC467459	29.33	34.67	24.67	33.39	38.49	62.67	29.16	15.71	260.67	75.00	9.69
CD at 5%	1.57	0.87	1.09	1.49	3.97	183.67	1.18	1.22	3.43	1.43	0.02
SEm	0.52	0.29	0.37	0.50	1.33	61.81	0.40	0.41	1.15	0.48	0.01

by 240.33 in EC467455, while minimum in EC467449 (183.33). Maximum days taken for maturity (75.00 days) were recorded in EC467459 followed by EC467439 and 467446 (74.67 days in each), while it was minimum in EC467447 and EC467449 (60 days in each). The fruit yield/plant was recorded highest in EC467459 (9.69 kg) followed by 6.88 kg in EC467455, whereas lowest fruit yield was recorded in EC467449 (3.52 kg). Findings of Mazumdar (1979), Singh (1985), Pal (1991) and Chandi (2000) also confirm variability of different genotypes of *Physalis* species in terms of yields per plant and individual fruit weight. Hernando and Leon (1994) and Singh *et al.* (2011) also reported great variation in fruit weight, colour and size of *Physalis ixocarpa* and *P. pereviana* cultivars under different agro zones.

Physico-chemical Characters

The different physico-chemical characteristics were studied and data values recorded for average fruit weight, husk weight, fruit husk ratio, firmness, TSS Brix, juice percent, acidity percent and ascorbic acid varied significantly (Table 5). The maximum fruit weight was recorded in EC467459 (37.67 g) followed by EC467455 (29.33 g) and it was recorded minimum in EC467449 (20.00 g). Maximum husk weight was recorded in EC467455 (0.34 g) followed by 0.33 g in EC467450 and minimum was recorded in EC467449 (0.20 g). Fruit husk ratio was recorded highest in EC467459 (121.5) followed by EC467440 (110.2) and lowest husk ratio was recorded in EC467450 (84.84). Fruit firmness was recorded highest in EC467459 (44.10 RI) followed by EC-467455 (37.87 RI) and lowest firmness was recorded in EC467445 (25.87 RI). Total soluble solids content ranged from 6.50-11.50°Brix and highest value was recorded in EC467440 (11.50°B) followed by 9.47°B in EC467439 and EC467459, and its lowest value (6.50° B) was found in EC467450 and EC467455 Singh *et al*. (1976) also observed similar kind of results in the ripe berries but not in conformity with Pal (1991), who reported the TSS levels of the fruit different from strains of husk tomato. Similar variation in TSS, acidity and ascorbic acid contents of cape gooseberry cultivars were also reported by Singh *et al.* (2011). This may be due to variation in climatic and growing conditions. The value of juice percentage of fruits ranged between (2.11 to 3.49 %) and maximum value was found in EC467459 (3.49%) followed by EC467455 (3.38%) and minimum juice percentage was found in EC467447 (2.11%). Such variation in the level in juice percentage in husk tomato is due to varietal differences, the same has also been reported by Karrer and Kahlon (2005). The titrable acid content in fruits was estimated the lowest 0.36% in EC467445 and the highest in EC467440 (1.51%). More or less similar values of acidity in husk tomato have been reported by Singh *et al.* (1976) and Pal (1991). According to Wolf (1991), the lowest value of acidity to the extent of such variations may be due to environmental condition particularly during the peak of growth and development of fruits or varietal differences. Ascorbic acid content was estimated maximum in EC467459 (24.27 mg/100 g) followed by 22.40 mg/100 gm in EC467450, however lowest ascorbic acid was estimated in EC467445 (15.40 mg/100 g).

Table 5. Physico chemical characteristics of husk tomato genotypes

Variety	Average fruit weight (g)	Husk weight (g)	Fruit husk ratio	Firmness (RI)	TSS (°Brix)	Juice (%)	Acidity (%)	Ascorbic acid (mg/100gm)
EC467435	27.67	0.30	92.2	36.23	8.50	2.66	0.46	18.60
EC467439	27.00	0.30	90.0	27.67	9.47	2.90	0.48	17.27
EC467440	28.67	0.26	110.2	36.67	11.50	3.09	1.51	15.87
EC467445	22.80	0.26	87.6	25.87	8.40	2.45	0.36	15.40
EC467446	25.67	0.27	95.0	26.63	7.63	2.14	0.38	16.80
EC467447	25.00	0.27	92.5	27.20	6.50	2.11	0.42	17.27
EC467449	20.00	0.20	100.0	31.77	7.57	2.83	0.37	16.80
EC467450	28.00	0.33	84.84	30.23	6.50	2.54	0.41	22.40
EC467455	29.33	0.34	86.26	37.87	6.50	3.38	0.41	21.40
EC467459	37.67	0.31	121.5	44.10	9.47	3.49	0.62	24.27
CD at 5%	1.12	0.15	0.44	3.92	0.45	0.48	1.72	2.40
SEM	0.37	0.05	0.14	1.32	0.15	0.16	0.57	0.80

Colour Value

The colour value of husk tomato fruits taken for L (brightness), a (redness), and b (yellowness) varied significantly with different genotypes (Table 6). The maximum 'L' value indicating brightness was found in EC467439 (64.15) followed by EC467455 (62.40) while minimum was found in EC467447 (46.56). The 'a' value indicating redness was recorded highest in EC467435 (-2.44), minimum was noted in EC467440 (-11.04), the 'b' value indicating yellowness was observed maximum in EC467440 (35.50) followed by EC467435 (32.27) however, the minimum value was recorded lowest in EC467447 (17.82). Variation in colour of fruit in husk tomato genotypes is reported by Hernando and Leon (1994), Heiser (1975); Dremann (1985) and in cape goose berry by Singh *et al.* (2011). Based on this research study, it can be concluded that EC 467459, 467455, 467440, 467435, 467439, 467446 and 467450 can be used as elite selections for the temperate regions. However, further studies are required for these selections and their evaluation so that potential for better utilization in the future way be established by devising complete package of practices for commercial cultivation in temperate region.

Table 6. Colour value of husk tomato genotypes

Variety	L *	a*	b*
EC467435	61.56	-2.44	32.27
EC467439	64.15	-6.70	27.18
EC467440	55.17	-11.04	35.50
EC467445	55.56	-7.59	23.54
EC467446	59.26	-6.54	26.65
EC467447	46.56	-4.77	17.82
EC467449	57.01	-5.58	23.75
EC467450	53.18	-8.58	23.82
EC467455	62.40	-7.65	29.72
EC467459	59.59	-6.62	26.69
CD at 5%	5.62	0.34	0.37
SEm	1.89	0.11	0.12

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