Variety Trials

Evaluation and Yield Trials of Tomatillo in New Hampshire

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SUMMARY. Five tomatillo (*Physalis ixocarpa* Brot. ex Hornem) cultivars available from commercial seed companies ('De Milpa', 'Puebla Verde', 'Purple Tomatillo', 'Tomatillo' and 'Toma Verde') and four *Physalis* L. accessions (PI 197691, PI 270459, PI 291560, and PI 309812) were grown in 1997 and 1998 at Kingman Research Farm, Durham, N.H. Three manual harvests per plot were performed each year, recording data of total fruit weight, number of fruit and average fruit weight for each genotype. There were statistically significant differences between tomatillo genotypes for all three traits. Statistically significant differences between the 2 years were found for fruit number and average fruit weight per genotype. Over both years, total fruit weight varied from 29.7 to 63.7 t·ha⁻¹ (13.3 to 28.4 ton/acre). Fruit numbers per plant varied from 83 to 330, and average fruit weight

varied from 18.0 to 38.3 g (0.6 to 1.3 oz). PI 197691 and PI 270459 performed better than some of the commercial cultivars indicating their potential to be used as germplasm for breeding. A basket-weave trellising system which kept plants upright was tested. This made harvest easier and potentially can be used for tomatillo culture.

Tomatillo or husk tomato is a herbaceous annual with indeterminate growth habit. It is native to Central America where it is claimed that there is no acceptable substitute in making green sauce or salsa verde (Saray-Meza et al., 1978). Three species of the genus *Physalis* have edible fruit with higher contents of protein, ascorbic acid, nicotinic acid and solids than tomato (Yamaguchi, 1983). *Physalis peruviana* L. (cape gooseberry, uchuba) and *P. pruinosa* L. (ground cherry, husk tomato) are used as juice and jam fruit; *P. ixocarpa* is used as a vegetable or for sauces. Tomatillo is adaptable to growing conditions in northern latitudes and has potential commercial value due to the increased popularity of Mexican food in the United States. In New Hampshire, most locally grown vegetables are sold retail through roadside stands and farmers' cooperative markets. Small farmers can profit from diversification and production of specialty crops such as tomatillo.

There have been studies on taxonomy and genetics (Menzel, 1951, Waterfall 1967, Quiros, 1984), self-incompatibility (Pandey, 1957), and development and growth of tomatillo (Cartujano-Escobar et al., 1985a, 1985b; Mulato-Brito et al., 1985). In Mexico many tomatillo cultivars are unnamed and considered criollas (native) and there are few named cultivars: 'De Milpa', with small and tart fruit, and 'Rendidora', developed by mass selection and having 35% of the total production in the country (Saray-Meza et al., 1978). In the United States, studies on field production of tomatillo were performed in Louisiana (Moriconi et al., 1990) using seeds from a single fruit (cultivar name not mentioned). We have found five tomatillo cultivars available from commercial seed companies in North America. 'Rendidora' was discontinued in the seed market before 1991 (Whealy, 1992), and other than 'De Milpa', we

do not know the origin of the other cultivars. Additionally, the USDA-ARS Plant Genetic Resources Unit at Geneva, N.Y., which holds the entire collection of *Physalis* in the United States, lists several *P. ixocarpa* accessions. The objectives of our study were to evaluate and conduct yield trials of tomatillo cultivars and available germplasm during the 1997 and 1998 growing seasons in New Hampshire. Results of an observation plot using a basket-weave trellising system are also reported.

Materials and methods

1997 EXPERIMENT. On 1 May 1997, five tomatillo cultivars from commercial seed companies ('Tomatillo', 'Puebla Verde', 'De Milpa', 'Toma Verde' and 'Tomatillo Purple') and 23 *Physalis* accessions were sown at the University of New Hampshire research greenhouses. Each genotype was sown in a six-pack plug tray using Pro-mix BX soilless medium (Premier Horticulture Ltée, Rivière-du-Loup, Québec, Canada). Three seeds were sown in each cell except where germination rate was indicated to be low, in which case up to 10 seeds per cell were used. The trays were put under mist watering in a greenhouse held at 21°C (70°F). When most of the seeds per tray germinated, the trays were moved into a greenhouse held at 17°C (63°F) and plants were thinned to one per cell.

Genotypes were transplanted to the field at the Kingman Research Farm, Durham, N.H., on 6 June to a plot with 3% to 8% slopes and Hollis-Charlton fine sandy loam (Charlton = coarse-loamy, mixed, mesic Entic Haplorthods; Hollis = loamy, mixed, mesic Entic Lithic Haplorthods). This plot had been broadcast-fertilized with 15N-6.6P-12.5K at a rate of 960 kg·ha⁻¹ (857 lb/acre) according to soil tests. Black plastic polyethylene mulch and drip irrigation (T-TAPE TSX, Rainflow Irrigation, East Earl, Pa.; 8 mil [0.008 inch (0.2 mm)]; emitters 20 cm (7.9 inches) apart) were used, with 1.8-m (6-ft) spacing between rows, and 0.6-m (2-ft) spacing between plants. Two replicated plots of 10 plants per genotype in a completely randomized design were used. Manual harvests were performed continuously from 20 Aug. to 25 Sept. 1997. A total of three harvests per plot were performed. After the first harvest, five of

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Table 1. Twenty-eight *Physalis* accessions and tomatillo cultivars grown in 1997 in New Hampshire.

Accession ^z	Species	Origin or seed company
G 30151	<i>P. ixocarpa</i>	Mexico
G 30152	<i>P. ixocarpa</i>	Mexico
G 30711	<i>P. ixocarpa</i>	Mexico
G 31141	<i>P. sp.</i>	Ecuador
PI 194590	<i>P. sp.</i>	Guatemala
PI 197691	<i>P. sp.</i>	Mexico
PI 197692	<i>P. sp.</i>	Mexico
PI 203924	<i>P. sp.</i>	Mexico
PI 232077	<i>P. peruviana</i> (Cape gooseberry)	Namibia
PI 270459	<i>P. ixocarpa</i>	Mexico
PI 285705	<i>P. peruviana</i> (Peruvian groundcherry)	Poland
PI 290968	<i>P. ixocarpa</i>	Argentina
PI 291560	<i>P. ixocarpa</i>	India
PI 291561	<i>P. peruviana</i>	India
PI 309812	<i>P. sp.</i>	Mexico
PI 360740	<i>P. ixocarpa</i>	USA
PI 512005	<i>P. ixocarpa</i>	Mexico
PI 512006	<i>P. ixocarpa</i>	Mexico
PI 512007	<i>P. ixocarpa</i>	Mexico
PI 512008	<i>P. ixocarpa</i>	Mexico
PI 512009	<i>P. ixocarpa</i>	Mexico
PI 512010	<i>P. ixocarpa</i>	Mexico
PI 512011	<i>P. ixocarpa</i>	Mexico
	<i>P. ixocarpa</i> (Tomatillo)	Burpee ^y
	<i>P. ixocarpa</i> (Tomatillo Puebla Verde)	Gurney's ^x
	<i>P. ixocarpa</i> (Tomatillo De Milpa)	Johnny's ^w
	<i>P. ixocarpa</i> (Tomatillo Purple)	Johnny's
	<i>P. ixocarpa</i> (Tomatillo Toma Verde)	Johnny's

^zAccessions obtained from Plant Genetic Resource Unit (Geneva, N.Y.).

^yW. Atlee Burpee and Co., Warminster, Pa.

^xGurney's Seed and Nursery Co., Yankton, S.D.

^wJohnny's Selected Seeds, Albion, Maine.

the *Physalis* accessions were selected, based on high yields, for subsequent harvests along with the commercial tomatillos. Two of selected accessions were listed as *P. ixocarpa* (PI 270459 and PI 291560), and the other three (PI 197691, PI 197692, and PI 309812) had no species identified. The rest of the accessions were found to have very small yields and no commercial value.

1998 EXPERIMENT. In 1998, five commercial tomatillo cultivars plus the five selected *Physalis* accessions were sown on 30 Apr. at the University of New Hampshire research greenhouses. The accession PI 197692 had a very low germination rate and did not have enough plants for field transplant. On 4 June a total of nine genotypes were transplanted to the field at the Kingman Research Farm into black plastic mulch on 15-cm (6-inch) raised beds fitted with drip irrigation. Before planting the plot was broadcast fertilized with 15N-3.5P-10K at a rate of 674 kg·ha⁻¹ (602

lb/acre) according to soil tests. Two replicated plots of 10 plants per genotype in a completely randomized design were used. Spacing between plots was increased to 2.4 m (8 ft). We selected five plants per genotype and recorded the date of first open flower, growth habit (40 d after transplant), mature fruit colors and fruit shape (three fruit per plant), and fruit diameter (measured on 10 fruit per plant using digital calipers). Three manual harvests per plot were performed between 26 Aug. and 29 Sept. 1998.

During both years, data were recorded on total fruit weight and number of fruit per plot. Total fruit weight was extrapolated to yield per hectare. Average fruit weight was calculated. Analyses of variance of total yield, fruit number and average fruit weight per plant over both years were performed using SAS (SAS Institute Inc., 1990). Mean separation was performed using the least significant difference (LSD) test.

BASKET-WEAVE TRELLIS EXPERIMENT.

An observation plot of 10 plants of 'Tomatillo' with a basket-weave trellis using stakes and twine (Konsler and Gardner, 1990) was included in the 1998 experiment. This plot was harvested three times along with the other plots, and the time required to harvest was recorded.

Results and discussion

GROWTH AND DEVELOPMENT. The 28 *Physalis* genotypes grown in 1997 are listed in Table 1. Plants grew very vigorously, eventually covering the space between rows. The only pest problem encountered was northern corn rootworm (*Diabrotica barberi* Smith & Lawrence) early in the season which was controlled with an application of carbaryl as a 10% dust. Most genotypes had indeterminate growth habit which became prostrate by the end of the season, making harvest very laborious. The only genotype with an upright growth habit was 'Purple Tomatillo'.

Table 2. Description of nine tomatillo genotypes grown in 1997 and 1998 in New Hampshire.

Cultivar or accession	Date of first flower (1998)	Upright habit	Mature fruit colors ^z	Fruit shape ^y	Fruit diam (cm) ^x
Tomatillo	8 June	No	G,Y	R,Ov	3.3
Puebla Verde	8 June	No	G,Y	R,Ov,Ob	3.4
Toma Verde	8 June	No	G,Y	R,Ov,Ob	3.3
De Milpa	24 June	No	G,G/P	R,Ov,Ob	2.6
Purple	15 June	Yes	G,P	R,Ov,Ob	2.9
PI 197691	12 June	No	G,Y	R,Ov	3.3
PI 270459	8 June	No	G,Y	R,Ob	3.7
PI 291560	8 June	No	G,Y	R,Ov,Ob	2.9
PI 309812	19 June	No	G,Y	Ov	4.5

^zG = green; Y = yellow; P = purple; G/P = green/purple.^yR = round; Ov = ovate; Ob = oblate.^xAverage of 50 fruit, 2.54 cm = 1.0 inch.**Table 3. Analyses of variance for total fruit weight, number of fruit per plant and average fruit weight of nine tomatillo genotypes over 1997 and 1998 in New Hampshire.**

Source	df	Mean square		
		Total fruit wt (t·ha ⁻¹) ^z	Fruit/plant (no.)	Avg fruit wt (g) ^y
Year	1	149.89	2048715.11 [*]	245.23 ^{***}
Cultivar	8	620.59 ^{***}	1742602.65 ^{***}	219.05 ^{***}
Year × cultivar	8	70.42	113213.36	13.78
Error	18	95.79	282131.67	13.91
Total	36			
CV(%)		21.99	29.73	12.8

^z2.24 t·ha⁻¹ = 1.0 ton/acre.^y28.35 g = 1.0 oz.^{*,***}Significant at P = 0.05 or 0.001, respectively.

In 1998 the five commercial tomatillo cultivars and four *Physalis* accessions with comparable yields were grown. In this season the only pest encountered was tomato hornworm (*Manduca quinquemaculata* Haworth) which was controlled with an application of *Bacillus thuringiensis* Berliner subsp. *kurstaki* (Thuricide, Bonide Products Inc., Yorkville, N.Y.). The wider spacing used between rows this year facilitated cultural operations and harvesting.

A description of the genotypes grown in 1998 can be found in Table 2. There was variation in the start of flowering. Some genotypes started flowering soon after transplanting, about 40 d after being sown. The latest was 'De Milpa', which started to flower when plants were about 55 d old. Although self-incompatibility has been reported in *P. ixocarpa* (Pandey, 1957), we obtained fruit with viable seeds by self pollinating emasculated flowers, and also from plants grown in the greenhouse in absence of pollinating insects. Mature fruit colors were green,

purple, green/purple or yellow. Fruit shapes were either round, ovate or oblate. Average fruit diameters varied from 2.6 cm (1.02 inches) in 'De Milpa', to 3.7 cm (1.45 inches) in PI 270459.

FRUIT YIELD. Fruit were considered ready for harvest when they had filled completely or were protruding from the husk. Partially rotted fruit and some of the largest fruit which were cracked were not included when recording total fruit weight. Each of the three harvests was spread over a period of time so statistical analyses were performed with the total data per genotype. The combined analysis of variance for the 2 years for total fruit weight, fruit number per plant and average fruit weight is shown on Table 3. There were statistically significant differences between tomatillo genotypes for all three traits. Statistically significant differences between the 2 years were found for fruit number and average fruit weight per genotype.

Results for total fruit weight per genotype, fruit number per plant and

average fruit weight are shown in Table 4. We found all tomatillo genotypes to be extremely productive. Total yield ranged between 29.7 to 63.7 t·ha⁻¹ (13.3 to 28.4 ton/acre). This was much higher than previous reports of 15 t·ha⁻¹ (6.7 ton/acre) for criolla types and 25 t·ha⁻¹ (11.2 ton/acre) for 'Rendidora' in Mexico, and 13.5 t·ha⁻¹ (6 ton/acre) in Louisiana (Moriconi et al., 1990). These authors reported yield losses of 20 to 40% due to plant viruses and lepidopterous insects. Another possibility for the differences in yield is that in our case, due to the amount of time and labor required for harvest, we found it was impossible to harvest all fruit when they were still green and at their prime marketable stage. Fruit that had already fallen off the plants were also picked up unless they were soft or rotten, and considered in the total yield.

Over the 2 years, 'Tomatillo' had the highest yields, followed by PI 197691, 'Puebla Verde', PI 270459, 'Toma Verde', 'Purple Tomatillo', PI 291560, 'De Milpa', and PI 309812.

Table 4. Total fruit weight, fruit number per plant, and average fruit weight of nine tomatillo genotypes grown in 1997 and 1998 in New Hampshire.

Cultivar or accession	Total fruit wt ^z (t·ha ⁻¹) ^w			Fruit/plant (no.) ^y			Avg fruit wt ^x (g) ^v		
	1997	1998	Avg	1997	1998	Avg	1997	1998	Avg
Tomatillo	65.1	62.3	63.7 a	204	212	208 b	34.3	31.9	33.1 bc
Puebla Verde	50.7	61.2	55.9 abc	137	191	164 b	41.8	34.7	38.3 ab
Toma Verde	36.0	49.7	42.9 cde	116	185	151 bc	33.5	28.6	31.1 cd
De Milpa	22.1	38.8	30.5 e	130	238	184 b	18.3	17.6	18.0 g
Purple	33.1	42.1	37.6 de	120	189	155 bc	30.0	24.1	27.1 de
PI 197691	58.9	58.6	58.8 ab	317	343	330 a	21.1	19.7	20.4 fg
PI 270459	48.4	42.9	45.6 bcd	137	183	160 bc	38.1	25.2	31.7 cd
PI 291560	36.5	35.5	36.0 de	148	200	174 b	27.3	20.0	23.7 ef
PI 309812	31.5	27.9	29.7 e	84	83	83 c	41.0	36.7	38.8 a

^zMeans not followed by the same letter are significantly different with LSD = 14.5.

^yMeans not followed by the same letter are significantly different with LSD = 78.9.

^xMeans not followed by the same letter are significantly different with LSD = 5.5.

^w2.24 t·ha⁻¹ = 1.0 ton/acre.

^v28.35 g = 1.0 oz.

In terms of fruit weight PI 309812 had the highest average, followed by 'Puebla Verde', 'Tomatillo', PI 270459, 'Toma Verde', 'Purple Tomatillo', PI291560, PI197691, and 'De Milpa'. 'De Milpa' had the smallest fruit, and also the lowest yield of all commercial cultivars. However its fruit do not crack and they stored best, remaining green and firm for up to 2 weeks, even at room temperature. Our results indicate the potential of some tomatillo accessions such as PI 19761 and PI 270459 for use as germplasm to develop commercial cultivars.

During the first year, we noticed that the biggest constraint for tomatillo production was the labor-intensive harvest due to the prostrate growth of plants. In 1998, we included an observation plot of 10 'Tomatillo' plants using a basket-weave trellising system. We thought that this system, often used with tomatoes (*Lycopersicon esculentum* Mill.), could make harvest easier by keeping plants upright. The first two harvests of this plot were timed and compared to the time required to harvest another plot of the same genotype without trellising. We found that on average, the time required to harvest 100 fruit was 2 h 37 min with the trellis versus 3 h 13 min without. More fruit were harvested from the trellised plot but total fruit

weight was slightly lower, resulting in an average fruit weight of 28.4 g (1 oz) with the trellis versus 32.7 g (1.2 oz) without. More replications would be needed to verify if these differences are consistent and statistically significant. However, in this initial study we noticed that harvest was more comfortable and easier with trellised plants and fruit that had fallen off the plants were not hidden under foliage. These results indicate the potential use for this trellising system for tomatillo culture.

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