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Evaluation of Seed Sources and Cultural Practices of Maxixe (Cucumis anguria L.) for Production in Massachusetts

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EVALUATION OF SEED SOURCES AND CULTURAL PRACTICES OF MAXIXE (CUCUMIS ANGURIA L.) FOR PRODUCTION IN MASSACHUSETTS

A Thesis Presented

by

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DEDICATION

To my patient and loving husband.

Renato, you are everything for me, without your love and understanding I would not be able to make it.

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I would like to thank God, first and foremost, for giving me the strength and determination to finish this thesis.

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This has truly been a unique and rewarding experience.

ABSTRACT

EVALUATION OF SEED SOURCES AND CULTURAL PRACTICES OF MAXIXE (CUCUMIS ANGURIA L.) FOR PRODUCTION IN MASSACHUSETTS

FEBRUARY 2011

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Maxixe (*Cucumis anguria* L.), also known as Burr gherkin and West Indian gherkin, was brought to Brazil from Africa during the slave trade. This crop was grown extensively in New England in the 18th and 19th centuries. There has been a tremendous increase of immigrants to the United States in recent years, and this has provided an opportunity for farmers to produce crops desired by these new and expanding markets. In order to benefit local farmers, two field experiments were implemented in 2009 and 2010 to address the effect of plant population, the use of a trellis and evaluate different seed sources of maxixe to assist producers interested in growing this crop in the Northeastern United States. The Trellis/Spacing trial was set up as a randomized–complete-block-split-plot design with five replications of 'Trellis' versus 'No Trellis' and within each trellis treatment there were five spacing between plants in the row: 15, 30, 45, 60, and 75 cm. The Seed Source trial was set up as a randomized complete block design with five replications and five sources of maxixe from five different seed companies: 'Isla', 'Feltrin', 'Topseed', 'HF', 'Seed Savers Exchange', and 'Baker Creek Heirloom Seeds'.

The five seed sources of maxixe are commercially viable for production in Massachusetts. The best plant spacing for marketable yield and marketable number of fruits was ‘15 cm’ in 2009; however, in 2010, the plant spacing that had the best marketable yield and the greater marketable number of fruits was ‘60 cm’ and ‘30 cm’, respectively. The use of trellis support indicated that the net returns on the ‘Trellis’ are higher than ‘No trellis’. However it is critical to understand the market preferences, such as size of the fruits and spines. This work speaks to the opportunities to supply the Brazilian markets and introduce this crop to non-Brazilian markets.

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CHAPTER1

INTRODUCTION

Maxixe (*Cucumis anguria* L.) is very similar to cucumber (*Cucumis sativus* L.) and is also known as burr gherkin and West Indian gherkin (Figure 1.1). The term gherkin is imprecise, since it has been used both for *C. anguria* and for small fruits of pickling cultivars of cucumbers (Robinson and Decker-Walters 1997). *Cucumis anguria* was previously considered to be the only species in the genus native to the Western Hemisphere, and its common name reflects its presumed origin in the Caribbean. It is now believed that this cultigen was introduced to the West Indies and Brazil from Africa by the slave trade (Robinson and Decker-Walters 1997).

Figure 1.1 Maxixe (*Cucumis anguria* L.) grown at the UMass Research Farm in 2009.

The fruits of maxixe, which are about the size and shape of a chicken egg, can have either supple spines or smooth skin and are pale green in color. The flowers, tendrils and lobed leaves of the bur gherkin are smaller than those of cucumber. The plants produce large quantities of fruits throughout the growing season (Robinson and Decker-Walters, 1997). The Brazilian populations of *C. anguria* are characterized by the production of large, smooth and non-bitter fruits. However, little genetic variability is observed among gherkin populations for plant and fruits traits, indicating that the genetic base is quite narrow (Paterniani & Costa, 1992).

Exact numbers of maxixe production are not readily available since it is considered a non-traditional vegetable and thus its yields are under-reported. According to CEASA-GO Monitoring of Conjectural Marketing, in 2009 approximately 146 tons of maxixe were sold in the state of Goiás, located in the Middle Western part of Brazil. Maxixe is especially popular in the Northeastern states of Brazil, where it is consumed boiled, fried, stewed or used fresh in salads. Maxixe is a valuable source of vitamins and minerals, and when consumed fresh, in salads, maxixe fruits are easier to digest than cucumbers (Resende, 1998).

The use of a trellis for vine crop production has some advantages, such as better disease management and fruit quality, increased plant longevity, and a longer harvest period, resulting in higher yield. The disadvantages of trellis production include increased labor and material costs (Filgueira 2008). Trellising is used to reduce contact of cucumber vines and fruit with bare soil to promote growth and limit mechanical and disease damage to fruit. Even when black plastic mulch is used, trellising improved yields over ground-cultured plants (Russo, 1991).

Shetty and Wehner (1998), evaluating oriental trellis cucumber for production in North Carolina, observed an increase in the marketable yield of cultivars grown in this system. Modolo & Costa (2004) found the use of trellis yielded fruits of Paulista gherkin (*Cucumis anguria* var. *anguria* x *C. anguria* var. *longaculeatus*) with better quality and facilitated more efficient harvesting compared to leaving the crop to grow on the ground. The trellis had vertical and horizontal strings, which allowed the secondary and tertiary shoots to be distributed evenly on the trellis. The trellis kept the fruit from contacting the soil, which makes for improved fruit quality and consequently reducing labor costs.

Oliveira (2010), evaluating the influence on yield of spacing between rows and between plants in the row, observed highest yields of commercial fruits of maxixe (16 and 12.9 t ha^{-1}) were obtained with 1.0 and 1.5m between plants and 2.0 and 1.0m between rows; the highest spacing between plants, 2.0m, reduced fruit productivity. In cucurbits, high plant populations can produce a large number of fruits per unit area, but low number of marketable fruits (Robinson and Decker-Walters 1997).

Research in the in the state of Pernambuco, Brazil reported a reduction in number of fruits per square meter with increasing plant density of pickling cucumber cultivars (Resendi and Flori, 2004). However, increasing plant density had only a small effect on the distribution of commercial fruit by number, but significantly increased the yield of commercial fruit, while decreasing that of the unmarketable large fruits on cucumbers (Nerson, 1998).

In Brazil, fruits of maxixe are most consumed in the North, Northeast and Middle West of the country, being sold daily in local markets and farmers market. However in

the South and part of Southeast areas, most of the sales of maxixe are intermittent. In consumer centers, such as São Paulo, where there is a large immigration from the Nnortheast, maxixe can be found more easily than in the interior cities. It is common to find plants of maxixe growing randomly among other crops, which production meets domestic consumption and local market, when there is demand (Oliveira, 2008).

There are two types of maxixe, one that has the fruits with fleshy spikes and other that the fruits are smooth. In the Amazon, in Brazil, the market does not depend on this feature. However in Rio de Janeiro market seems to have a higher preference for the smooth variety (Resende, 1998). Maxixe is grown year around in the state of Maranhão, Brazil, with average yield of 16t.ha^{-1} in most of the year, but the planting area was reduced in the rainy season, while yield also decreased to 8-10 t.ha^{-1} (Resende, 1998).

This crop is well-adapted to soils with low fertility and low pH and is best adapted to well-drained sandy soils. In Brazil, it is common to not apply fertilizer when growing this crop since the residue from previous crops will suffice. However, in soils with low fertility, it is recommended to apply 30 kg of N, 140 kg of P_2O_5 and 50 kg of K_2O per hectare (Filgueira, 2008).

The New England Vegetable Management Guide (New England Vegetable Management Guide, 2008-2009) recommendations for Cucumber, Muskmelon and Watermelon suggest that for soils with high phosphorus levels and very high potassium levels, 145k/g of N ha^{-1} and 45kg of P_2O_5 ha^{-1} should be applied to the soil. In work implemented in the state of Paraiba, Brazil, rates of nitrogen above 188kg ha^{-1} led to a significant reduction in fruit production, which the authors attributed to excessive amounts of this nutrient (Oliveira et al, 2008).

This crop was grown extensively in New England in the 18th and 19th centuries. The burr gherkin was introduced into the United States by Minton Collins of Richmond, Virginia, in 1793. The popularity of pickled burr gherkins spread quickly. The benefits of the gherkin were its productivity and lower insect damage compared to other cucurbits; it could be counted on when other cucumbers might fail (Weaver, 1998). Maxixe can be grown in Massachusetts using the same production practices as cucumbers. Maxixe is a frost sensitive crop, as all cucurbits, and should be seeded or transplanted after the threat of frost has passed. If starting as transplants, they should be started in the greenhouse four weeks before being set out in the field (Mangan, 2010).

New England has one of the largest Brazilian populations in the United States. According to the Brazilian Ministry of International Relations (Brasileiros no Mundo, 2009) there are about 350,000 Brazilians living in the states of Massachusetts, Maine, New Hampshire, Rhode Island and Vermont. Farmers in Massachusetts are always interested in new markets and in order for them to be able grow crops popular among Brazilians, they need to learn how to produce and market Brazilian crops.

In order to benefit Massachusetts farmers, this work has the following objectives:

1. Evaluate the production of different seed sources of maxixe in Massachusetts.

2. Evaluate cultural practices for optimum maxixe production in Massachusetts.

CHAPTER 2

PRELIMINARY MARKET ANALYSIS OF MAXIXE (*CUCUMIS ANGURIA* L.) PRODUCED IN MASSACHUSETTS

Farmers rightfully see the introduction of new crops to their crop mix as a challenge, beginning with the availability of seeds to the different production practices that they must learn and implement in order to grow them successfully. There can also be considerable risk in growing new crops without a thorough understanding of their market potential. It is essential that the farmers understand the market demand for a specific crop, and the distribution system used to deliver the crops to the consumer, before planting the seed (Mangan, 2008).

In some cases it is very difficult to introduce ethnic crops to traditional markets due to the unusual taste to consumers that are not of the ethnic group that uses this crop. In some cases, however, there is interest in something that is "new". It was felt that maxixe potentially falls in this category and has been test-marketed by UMass in several traditional markets with some success. Maxixe has the potential to be accepted by the non-Brazilian market due to its unique shape and flavor, and the fact that it is easy to prepare, including being used raw in salads, and is low in calories.

As part of the preliminary work on the introduction of maxixe to commercial farms in Massachusetts, several surveys with target markets were implemented in order to evaluate the non-Brazilian market potential for maxixe. These surveys were implemented on Martha's Vineyard as part of a larger project to introduce vegetables popular among Brazilians to commercial farmers, backyard gardeners and markets on this island off the coast of Massachusetts. Martha's Vineyard has a large Brazilian population,

estimated to be as high as 3,000, which represents 20% of the population (BBC NEWS, 2009).

In 2009, four cooperating Massachusetts farmers located in Lancaster, Deerfield, Methuen and Edgartown (Martha's Vineyard), grew maxixe to evaluate the production and market potential of this crop, both for the Brazilian market and for the non-Brazilian market. Maxixe produced by cooperating growers was sold in three chain stores, some smaller ethnic markets and at farmers' markets in Massachusetts. Farmers were given promotional materials in English and Portuguese to let their customers know about maxixe, including nutritionally-balanced recipes produced by the UMass Nutrition Education Team. One farmer growing maxixe was able to sell it at their farm stand and also to a local market (Fig. 2.1).

Figure 2.1 Maxixe for sale in a local market in Martha's Vineyard in 2009.

Four events were held on Martha's Vineyard to promote maxixe in addition to other vegetables popular among Brazilians at Cronigs Market (Vineyard Haven MA) (Fig. 2.2). The events occurred on 25, 26 July, and 22, 23 August of 2009, where surveys were conducted with participants to gain an understanding of their interest and willingness to purchase these locally-grown vegetables. Participants were asked how likely they would be to purchase maxixe after tasting the dish prepared with maxixe, called "Maxixe salsa", at the four events. Sixty-seven percent of those surveyed said they would be "very willing" to purchase maxixe (Fig. 2.3).

Figure 2.2 Brazilian taste test event hold Cronig's Market in Martha's Vineyard in 2009.

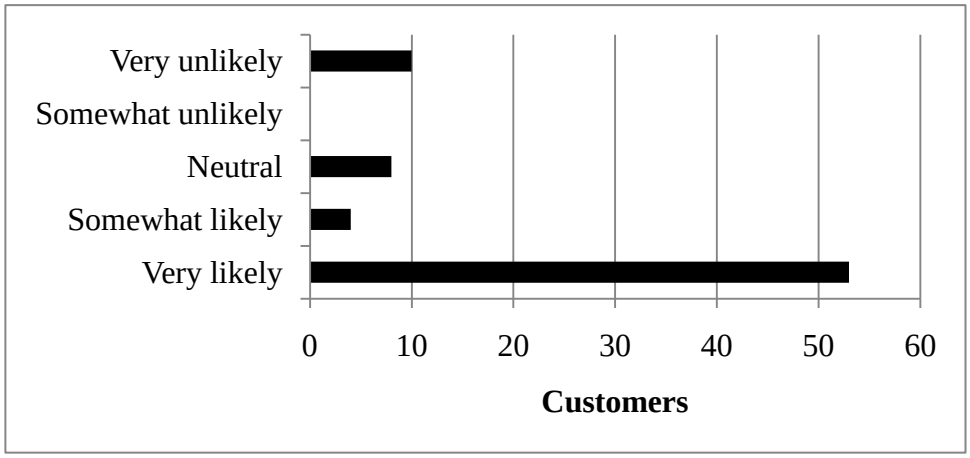

Figure 2.3 Likelihood to purchase maxixe after sampling dish made with this vegetable (Maxixe salsa)**.** *Survey conducted with 78 consumers at a store in Martha's Vineyard (Vineyard Haven) in 2009.*

When asked about visual appearances of the maxixe fruits, 50% of the respondents preferred the spiny type, 46% preferred the smooth type and 4% had no preference (Fig.2.4). This work speaks to the opportunities to introduce maxixe to non-Brazilian markets. In order to have success with non-Brazilian markets, there needs to be similar promotional events in order to introduce maxixe successfully in the market.

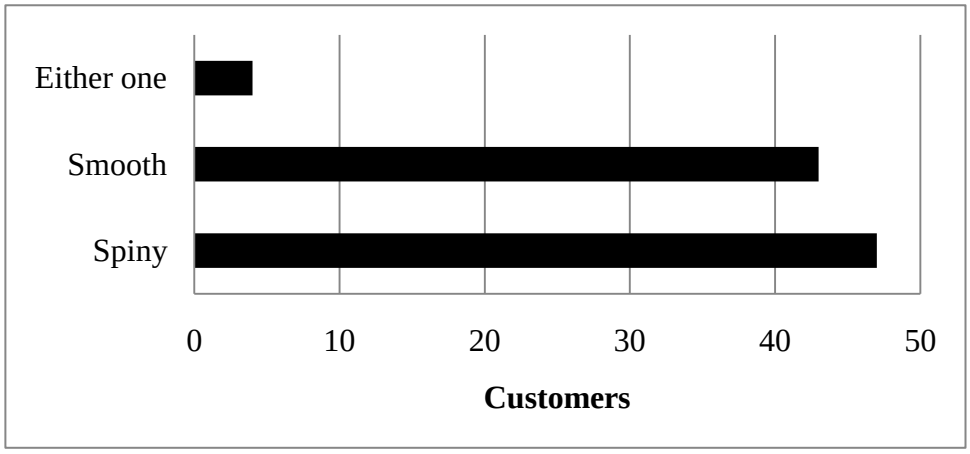

Figure 2.4 Preference of visual fruits of maxixe. *Survey conducted with 94 consumers at a store in Martha's Vineyard (Vineyard Haven) in 2009.*

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CHAPTER 3

EVALUATION OF SEED SOURCES OF MAXIXE (*CUCUMIS ANGURIA* L.) FOR PRODUCTION IN MASSACHUSETTS

3.1 Introduction

Maxixe (*Cucumis anguria* L.), also known as Burr gherkin and West Indian gherkin, was brought to Brazil from Africa during the slave trade. In Brazil, fruits of maxixe are most consumed in the North, Northeast and Middle West of the country, where they are sold daily in local markets and farmers markets. In the South and parts of Southeastern Brazil, sales of maxixe are intermittent. In consumer centers, such as São Paulo, where there is a large immigration from the Northeast, maxixe can be found more easily than in the interior cities (Oliveira, 2008a). Plants of maxixe are commonly found growing as volunteers among other crops and this production meets the demand of local market (Azevedo & Melo, 2003; Oliveira, 2008b).

There are two types of maxixe in Brazil; one that has the fruits with fleshy spikes and a second that is smooth. In the Amazon region of the Brazil, the market does not have a preference for either type of maxixe; however, in Rio de Janeiro the market has a higher preference for the smooth type (Resende, 1998). Maxixe is grown year-round in the state of Maranhão, Brazil, with average yield of 16 $t.ha^{-1}$ most of the year; however, the planting area is reduced during the rainy season, when yields decrease to 8-10 $t.ha^{-1}$ (Resende, 1998). This crop was grown extensively in New England in the 18th and 19th centuries, where it was eaten raw and also pickled for consumption in the winter (Weaver, 1998).

There has been a tremendous increase of immigrants to the United States in recent years, and this has provided an opportunity for farmers to produce crops desired by these new and expanding markets. Farmers are always interested in new markets and in order for them to produce and market crops popular among the growing immigrant populations, they need research-based information on how to grow these crops and how well they grow in the Northeastern US. New England has one of the largest Brazilian populations in the United States. According to the Brazilian Ministry of International Relations (Brasileiros no Mundo, 2009) there are about 350,000 Brazilians living in the states of Massachusetts, Maine, New Hampshire, Rhode Island and Vermont. Research at the University of Massachusetts has been implemented on two other crops popular among Brazilians, jiló (*Solanum gilo*) and abóbora japonesa (*Cucurbita maxima x Cucurbita moschata*), which have allowed the successful adoption of these crops by commercial farmers (Mendonca, et. al., 2006 and 2007).

The focus of this work was to evaluate several sources of maxixe for production in Massachusetts.

3.2 Material and Methods

The field experiments were conducted in 2009 and 2010 at the UMass Research Farm in South Deerfield, MA. The soil at the UMass Research Farm is an Occum fine sandy loam (coarse-loamy, mixed, mesic Fluventic Dystrudept).

In both years, this experiment was set up as a randomized complete block design with five replications and five sources of maxixe from five different seed companies: ‘Isla’ (Porto Alegre Brazil), ‘Feltrin’ (Farroupilha Brazil), ‘Topseed’ (Petropolis Brazil),

'HF' (Whately MA), 'Seed Savers Exchange' (Decorah IA) and 'Baker Creek Heirloom Seeds' (Mansfield MO). In 2009, the following seed sources were used: 'Isla', 'Feltrin', 'Topseed', 'HF', and 'Baker Creek'. In 2010, 'HF' was replaced by 'Seed Savers', due to the fact that HF is an old seed source that is no longer available in the market. For the Brazilian companies, 'Isla', 'Feltrin' and 'Topseed', the seed source is called "Maxixe do Norte". The seed source from Baker Creek Heirloom Seeds is called "West India Burr Gherkin" and "West India Gherkin" by Seed Savers Exchange.

Seedlings were produced in peat pots with 72 cells in 2009 and in round plastic flats with 72 cells in 2010 trials. Pro-Mix Bx (Premier Horticulture Québec Canada) was used as growing medium. Three seeds of each variety were placed in each cell and thinned to two plants/cell two weeks after seeding. The flats were in a mist house (24 ^{o}C day and night temperatures) until germination, and then transferred to a greenhouse (21 ^{o}C day and 18 ^{o}C night temperatures) with a regime of water and fertilizer (Technigro 17-5-24, 200 ppm Nitrogen) as a constant feed system. Plants were transplanted to the field 25 days after seeding in the greenhouse in 2009 and 26 days in 2010. Due to the poor germination of two seed sources in 2010, there are two seedling dates and two different planting dates, where the second planting is called "Late Seed Sources"(Table 4.1).

Table 3.1 Dates for selected actions for maxixe grown in 2009 and 2010 at the UMass Research Farm in Deerfield, MA.

Action	2009	2010	2010 Late Seed Sources
Seeded in the greenhouse	May 18	May 7	May 14
Thinned in the flats	June 2	May 21	May 28
Transplanted into the field	June 12	June 2	June 9
First Harvest	July 15	July 6	July 6

Each plot measured 3.05m X 3.66m with plugs 61cm apart, totaling 10 plugs per plot. Each transplant plug had two plants and was arranged in double rows on 8 cm raised beds with black plastic mulch spaced 3.66m on center.

In both years, water was applied via drip irrigation as needed based on soil moisture readings from tensiometers (Irrometer Co Riverside CA) placed at 15, 30, and 45 cm depths in the soil next to the plants.

Fertilizer was applied through the drip system in the form of a complete fertilizer (20%N-20%P_2O_5-20%K_2O) and calcium nitrate (15.5%N-0%P_2O_5-0%K_2O) according to soil tests taken in the early spring and based on the recommendations from the New England Vegetable Management Guide 2008-2009 for cucumbers. The total amount of fertilizer applied through the drip system during the 2009 and 2010 experiments was ($kg.ha^{-1}$): 130 N, 15.7P, 15.7 K and 117.2N, 37.3P, 34.8K, respectively. Weeds between plastic covered beds were removed by hand. Cutworms were found in the 2009 experiment and the applications of Asana XL (active ingredient:esfenvalerate) at rate of 630g/ha on 15 and June 29. Striped cucumber beetle (*Acalymma vittatum*) was controlled in 2010 by one application of Admire 2F (1.46 liters/ha; a.i. imidacloprid) applied through the drip system on June 21, and one application of Sevin XRL Plus (2.33 liters/ha; a.i. carbaryl) on June 22.

Harvest began 33 days after planting in 2009, 34 days after planting in 2010 for the first planting and 27 days after planting for the late varieties, when the fruits reached 5-7 cm in length (the size desired by the Brazilian market). Harvests occurred twice a week for the first five weeks in both years and then once per week for the last three

weeks of the season due to slower fruit production. For each harvest, the number and weight of fruit from an 8.9 m^2 sample area of the middle of each plot were taken. Marketable fruit were separated from unmarketable fruit based on size, color and damage. A sub-sample of five fruits per plot was randomly chosen to measure fruit length, fruit weight, fruit diameter and length of spines using a digital caliper. Analyses of variance were performed by SAS and the means compared using Duncan's new multiple range test ($P = 0.05$).

3.3 Results and discussion

Significant differences were observed between total and marketable yield ($t.ha^{-1}$) for five and eight weeks of harvest in 2009 and 2010 (Table 3.2). In both years, 'Feltrin' had the higher total and marketable yield after both five and eight weeks. In 2009, the total yield of 'Feltrin' after eight weeks was 38.4 $ton.ha^{-1}$ and 42.2 $ton.ha^{-1}$ in 2010, which were more than 37% and 77% higher than the other seed sources in 2009 and 2010, respectively. These yields were lower than those found by Modolo & Costa (2003) when evaluating 'Maxixe Paulista' lines, with 6,500 $plants.ha^{-1}$, that yielded 51.9$t.ha^{-1}$. Feltrin also had the highest marketable yield after eight weeks in both years, with a yield of 17.6 $ton.ha^{-1}$ in 2009 and 28.3 $ton.ha^{-1}$ in 2010. In 2009, there were no statistical differences among 'Baker', 'Isla', 'HF' and 'Topseed' for total or marketable yield after eight weeks, with the marketable yield varying between 12.6 and 13.3 $ton.ha^{-1}$. In 2010, for both total and marketable yield after eight weeks there were no statistical differences between 'Isla' and 'Savers' and no difference between 'Baker' and 'Topseed'. However 'Isla' and 'Savers' had greater yield than 'Baker' and 'Topseed' In 2009, no significant differences

were observed among the five seed sources in total and marketable number of fruits per plant after eight weeks.

Analyzing the fruits characteristics for the experiment in 2009, statistical differences were found among the five seed sources of maxixe after eight weeks of yield (Table 3.2). 'Feltrin' had the greater value for the fruit weight, length, diameter and spines; there were no statistical differences among the other four seed sources after eight weeks. The mean fruit weight for 'Feltrin' after eight weeks was 45.3 grams and the other four seed sources varied from 33.5 to 34.5 grams. 'Feltrin' had the greater length of spines over all, with 4.8 mm, compared to Isla with 1.8 mm, 'Topseed' with 1.7 mm, 'HF' with 1.7 mm and 'Baker' with 1.6 mm. In 2010, there were also significant differences in fruit weight, length, diameter and spines after eight weeks of yield (Table 3.3).

Table 3.2 Total yield and fruit number for marketable and non-marketable maxixe fruit harvested over five and eight weeks at the UMass Research Farm in Deerfield MA in 2009 and 2010.

	Yield *(ton.ha$^{-1)}$*				Number of fruits *(Fruits/plant)*			
	Total		Marketable		Total		Marketable	
Source	5 weeks	8 weeks	5 weeks	8 weeks	5 weeks	8 weeks	5 weeks	8 weeks
				2009				
Feltrin	26.2 a	38.4 a	17.3 a	17.6 a	1 .9 a	174.2 a	81.4 a	83.4 a
Isla	16.6 b	26.9 b	11.6 b	13.1 b	105.4 a	174.6 a	73.4 a	82.9 a
Topseed	17.6 b	28.0 b	11.6 b	12.7 b	109.1 a	179.4 a	71.8 a	79.0 a
Baker	17.7 b	27.0 b	12.5 b	13.3 b	100.9 a	168.1 a	68.1 a	74.2 a
HF	17.7 b	26.5 b	11.5 b	12.6 b	112.7 a	177.4 a	73.3 a	80.8 a
				2010				
Feltrin	31.9 a	42.2 a	26.0 a	28.2 a	144.6 a	182.1 a	121.2 a	129.0 a
Isla	16.3 b	24.2 b	12.4 b	13.9 b	98.8 b	137.6 b	77.1 b	84.4 b
Topseed	7.2 c	17.3 c	4.4 c	6.1 c	43.3 c	90.7 c	27.9 c	35.4 c
Baker	8.3 c	17.9 c	4.7 c	6.1 c	51.1 c	100.1 c	30.4 c	37.7 c
Savers	14.2 b	22.0 b	10.4 b	11.8 b	86.8 b	127.0 b	65.6 b	72.8 b

Means separation in columns and year by Duncan's new multiple range test, P=0.05.

Table 3.3 Fruit weight (grams), length (mm), diameter (mm), and spines (mm) of different seed sources of maxixe harvested in 5 and 8 weeks.

	Fruit Characteristics 8 weeks				Fruit Characteristics 5 weeks			
Source	Weight *(grams)*	Length *(mm)*	Diameter *(mm)*	Spines *(mm)*	Weight *(grams)*	Length *(mm)*	Diameter *(mm)*	Spines *(mm)*
				2009				
Feltrin	45.3 a	58.1 a	37.6 a	4.8 a	45.4 a	57.6 a	38.2 a	5.3 a
Isla	33.5 b	52.0 b	34.1 b	1.8 b	33.8 b	52.0 b	34.4 b	1.9 b
Topseed	34.5 b	51.9 b	34.5 b	1.7 b	35.2 b	52.1 b	34.9 b	1.8 b
Baker	34.3 b	51.2 b	34.4 b	1.6 b	35.8 b	51.3 b	34.9 b	1.7 b
HF	33.7 b	51.5 b	34.4 b	1.7 b	34.5 b	51.7 b	35.0 b	1.8 b
				2010				
Feltrin	48.1 a	59.9 a	38.0 a	3.1 a	44.5 a	59.2 a	37.5 a	3.1 a
Isla	35.9 b	53.8 bc	35.1 bc	1.4 b	33.2 b	53.2 bc	34.5 b	1.3 b
Topseed	36.9 b	54.2 b	35.3 b	1.4 b	32.1 b	53.4 b	34.3 b	1.4 b
Baker	35.0 b	53.5 bc	34.6 c	1.4 b	31.7 b	52.6 bc	33.6 c	1.3 b
Savers	34.9 b	53.1 c	34.8 bc	1.4 b	32.1 b	52.1 c	34.1 bc	1.3 b

Means separation in columns and year by Duncan's new multiple range test, P=0.05.

'Feltrin', after eight weeks, had the greatest value of weight and spines with 48.1 grams and 3.1 mm, respectively, compared to the other seed sources that were not differences for those fruits characteristics. 'Feltrin' had the longest fruit (59.98 mm) compared the other four seed sources. There were no statistical differences among 'Topseed', 'Baker' and 'Isla' in fruit length. The greatest fruit diameter was 38.0 mm for 'Feltrin' and the smallest fruit diameter was 34.6 mm for 'Baker'. There were no differences in diameter among 'Isla', 'Savers' and 'Topseed'.

The size of maxixe fruit will affect the time and effort needed to harvest a certain quantity. In Massachusetts, maxixe is sold wholesale in a ½ bushel box with 7kg of fruits, while at a farmers markets, where maxixe is sold retail, maxixe is available in bunches with 7-10 fruits each. The size and weight of individual maxixe fruit will impact the return that farmers will receive from their sales, given a set price regardless of size.

There were two peaks of yield in both 2009 and 2010 over the eight weeks of production (Figs. 3.1 and 3.2). In 2009, all seed sources increased in yield between the first and third weeks of harvest, when the first peak occurred; 'Feltrin' had the highest peak and 'Baker' had the lowest (Figure 3.1). The second peak was observed at the sixth week and from this peak until the eighth week of harvest there was a decrease in yield for all seed sources. In 2010, the first peak of production for 'Feltrin' was observed at the fourth week and at the fifth week for the other seed sources (Fig. 3.2). After the first peak, all five seed sources had a decrease in yield until the sixth week of harvest. The second and lower peak in 2010 occurred on the seventh week of harvest for all the seed sources. 'Seed Savers' and 'Isla' had similar performances during the 8 weeks, but 'Isla' had higher yield in both peaks.

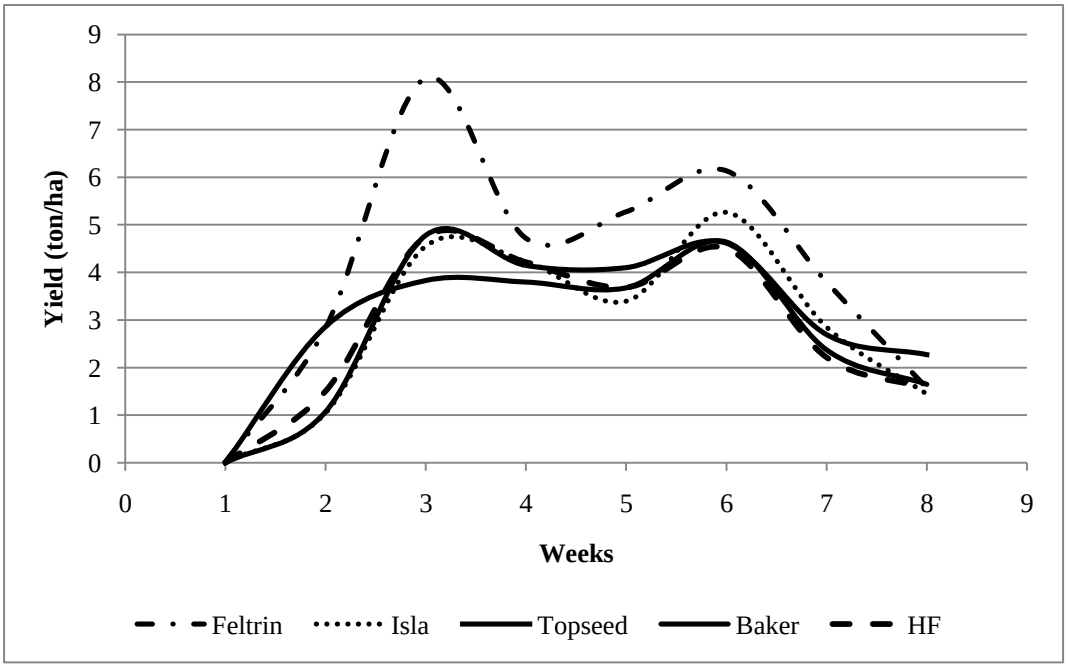

Figure 3.1 Total yield per week of maxixe for 5 seed sources in 8 weeks of harvest at the UMass Research Farm in Deerfield, MA in 2009.

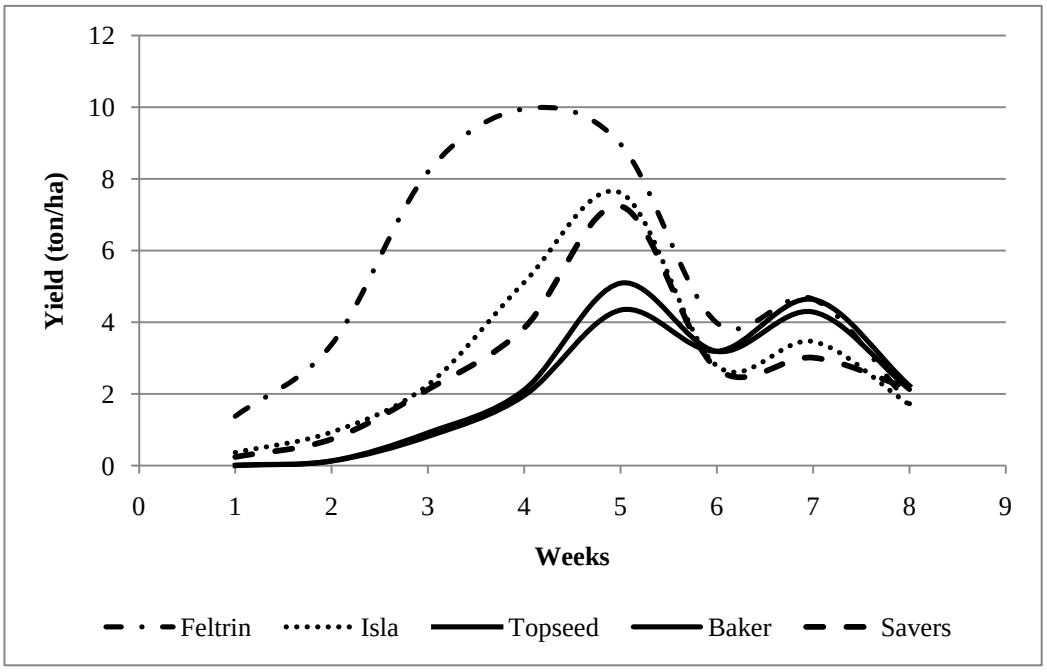

Figure 3.2 Total yield of maxixe for 5 seed sources in 8 weeks of harvest at the UMass Research Farm in Deerfield, MA in 2010.

There was an interaction of year and the two seed sources, 'Feltrin' and 'Isla', that were produced in both years and seeded at the same time (Table 3.4).. In 2009, 'Feltrin' produced 43% more total yield than that of 'Isla' with yield of 38.4 ton.ha^{-1} and in 2010 the total yield for 'Feltrin' was 42.2 ton.ha^{-1} which was 74% higher than 'Isla'. Marketable yield of 'Feltrin' was greater than 'Isla' in both 2009 and 2010. There were no statistical differences among 'Feltrin' and 'Isla' for either total or marketable numbers of fruits in 2009. The total and marketable numbers of fruits in 2010 differed statistically among 'Feltrin' with 182.1 and 129.0 total and marketable fruits per plant, respectively, and 'Isla' with 137.6 and 84.4 total and marketable fruits per plant.

The increase on total and marketable yield for both 'Feltrin' and 'Isla' in 2010 may be due to the difference in weather conditions in the two seasons. In 2009, the period

during the cultivation of maxixe was unseasonably cool, cloudy and wet, with 366 mm of rainfall and 804 accumulated growing degree days (GDD). In 2010, the summer was warm and dry, with 150 mm of rainfall and 1025 GDD. The higher temperatures and lower rainfall in 2010 are speculated to be responsible for the higher yields observed compared to 2009.

Table 3.4 Variety over year

	Yield *(ton.ha^{-1})*		Number of fruits *(Fruits/plant)*	
Source	Total	Marketable	Total	Marketable
		2009		
Feltrin	38.4	17.6	174.2	83.4
Isla	26.9	13.1	174.6	82.9
		2010		
Feltrin	42.2	28.2	182.1	129.0
Isla	24.2	13.9	137.6	84.4
Results of ANOVA (P $\geq$ F)				
Seed Source (S)	<0.0001	<0.0001	0.0148	0.0012
Year (Y)	0.7453	0.0228	0.1241	0.0577
Y X S	0.0490	0.0008	0.0136	0.0014

Yield results suggest that the five seed sources of maxixe are commercially viable for production in Massachusetts. Maxixe can be grown up to eight weeks in the field; however, due to the fact that there is a potential for fruits to get bitter with plant maturity, it is recommended that farmers to harvest marketable fruits at most until the fifth week of production in order to get the best quality from each planting. For this reason it is recommended have two-three plantings for production in Massachusetts to ensure good quality fruit throughout the growing season.

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CHAPTER 4

CULTURAL PRACTICES OF MAXIXE (*CUCUMIS ANGURIA* L.) FOR PRODUCTION IN MASSACHUSETTS

4.1 Introduction

Maxixe (*Cucumis anguria* L.) is very similar to cucumber (*Cucumis sativus*) and is also known as Burr gherkin and West Indian gherkin. Maxixe is especially popular in the Northeastern states of Brazil, where it is consumed boiled, fried, stewed or used fresh in salads. Maxixe is a valuable source of vitamins and minerals, and when consumed fresh it is easier to digest than cucumbers (Resende, 1998).

The use of a trellis for vine crop production has some advantages for production, such as better disease management and fruit quality, increased plant longevity, and longer harvest period, all of which can result in higher yields. Some disadvantages of the use of trellis production include increased labor and material costs (Filgueira 2008). Trellising is sometimes used to reduce contact of cucumber vines and fruit with bare soil to promote growth and limit mechanical and disease damage to fruit. Even when black plastic mulch is used, trellising improved yields over ground-cultured plants (Russo, 1991). Modolo & Costa (2004) found the use of a trellis yielded fruits of Paulista gherkin (*Cucumis anguria* var. *anguria* x *C. anguria* var. *longaculeatus*) with better quality and facilitated more efficient harvesting compared to leaving the crop to grow on the ground. Shetty & Wehner (1998), evaluating the use of a trellis with oriental trellis cucumber (*Cucumis sativus* L.) for production in North Carolina, observed an increase in the marketable yield of cultivars grown with a trellis compared to bare ground.

Oliveira (2010), evaluating the influence of plant spacing between rows and between plants in the row on yield, observed the highest yields of commercial fruits of maxixe (16 and 12.9 t ha^{-1}) were obtained with 1.0 and 1.5m between plants and 2.0 and 1.0 between rows and the highest spacing between plants 2.0 m reduced fruit productivity. When plants were spaced 2.0 m apart in the row, this resulted in a reduction in the number of fruits per plant compared to other spacing. In cucurbits, high plant populations can produce a large number of fruits per unit area, but low number of marketable fruits (Robinson and Decker-Walters 1997).

Maxixe was grown extensively in New England in the 18th and 19th centuries (Weaver, 1998). Maxixe can be grown in Massachusetts using the same production practices as cucumbers and like other cucurbits, and should be seeded or transplanted after the threat of frost has passed (Mangan, 2010). According to the Brazilian Ministry of International Relations (Brasileiros no Mundo, 2009), there are about 350,000 Brazilians living in New England. This large and growing Brazilian population in Massachusetts has a strong preference for their traditional cuisine, and this represents a market with strong potential for local producers (Mendonca, 2007).

This research was implemented to address the effect of plant population and the use of a trellis to assist producers interested in growing this crop in the Northeastern United States.

4.2 Material and Methods

The field experiments were conducted in the summers of 2009 and 2010 at the UMass Research Farm in South Deerfield, MA. The soil at the UMass Research Farm is an Occum fine sandy loam (coarse-loamy, mixed, mesic Fluventic Dystrudept).

In both years, this experiment was set up as a randomized–complete-block-split-plot design with five replications of 'Trellis' versus 'No Trellis' and within each trellis treatment there were five spacing between plants in the row: 15, 30, 45, 60, and 75 cm. A lightweight polypropylene netting with 15 cm squared mesh and one meter high was used as a trellis; it was attached to wooden tomato stakes, 1.5 meters tall, spaced every 1.5 meters in the row.

Seedlings were produced in round plastic flats with 72 cells (91 cm cubed/cells). Pro-Mix Bx (Premier Horticulture) was used as growing medium. Three seeds of "Maxixe do Norte" (Seed source: Feltrin - Farroupilha Brazil) were placed in each cell and thinned to two plants/cell two weeks after seeding. The flats were placed in a mist house (24 ^{o}C day and night temperatures) until germination, and then transferred to a greenhouse (21 ^{o}C day and 18 ^{o}C night temperatures) with the regime of fertilizer (Technigro 17-5-24, 200 ppm Nitrogen) applied as a constant feed. Plants were transplanted to the field 23 days after seeding in the greenhouse in 2009 and 26 days in 2010 (Table 4.1).

Table 4.1 Dates for selected actions for maxixe grown on the Density/Trellis trial in 2009 and 2010 at the UMass Research Farm in Deerfield MA.

Action	2009	2010
Seeded in the greenhouse	May 20	May 7
Thinned in the flats	June 4	May 21
Transplanted into the field	June 12	June 2
First Harvest	July 15	July 6

Each plot measured 1.83m X 3.05m and the quantity of plants within each plot varied with the density of the plants. Each transplant plug had two plants and was set in the center of an 8 cm raised beds with black plastic mulch spaced 1.83m on center.

In both years, water was applied via drip irrigation as needed based on soil moisture readings from tensiometers (Irrometer Co Riverside CA) placed at 15, 30, and 45 cm depths in the soil next to the plants.

Fertilizer was applied through the drip system in the form of a complete fertilizer (20%N-20%P_2O_5-20%K_2O) and calcium nitrate (15.5%N-0%P_2O_5-0%K_2O) according to soil tests taken in the early spring, based on the recommendations from the New England Vegetable Management Guide 2008-2009 for cucumbers. The total amount of fertilizer applied through the drip system during both years of experiments was ($kg.ha^{-1}$): 125.2 N, 16.3P, 16.3 K for 2009 and 111.7N, 35.6P, 33.2K in 2010. Weeds in-between plastic were removed by hand. Cutworms were found in the 2009 experiment and two applications were made with Asana XL (active ingredient:esfenvalerate) at rate of 630g/ha on June 15 and 29. Striped cucumber beetle (*Acalymma vittatum*) was controlled in 2010 by one application of Admire 2F (1.46 liters/ha; a.i. imidacloprid) applied through the drip system on June 21, and one foliar application of Sevin XRL Plus (2.33 liters/ha; a.i. carbaryl) on June 22.

Harvest began 33 days after planting in 2009 and 34 days after planting in 2010, when the fruits reached 5-7 cm in length (the size desired by the Brazilian market). Harvests occurred twice a week for the first five weeks in both years and then went to once a week for the last three weeks of the season due to slower fruit production. For each harvest, the number and weight of fruit from a 2.8 m^2 sample area in the middle of each plot was taken. Marketable fruit was separated from unmarketable fruit based on size, color and damage present in the fruits. A sub-sample of five fruits per plot was randomly chosen to measure fruit length, fruit weight, fruit diameter and length of spines using a digital caliper. Analyses of variance were performed by SAS and the means compared using orthogonal comparisons.

4.3 Results and discussion

In 2009, total and marketable yield and total and marketable number of fruits were not affected by trellising (Table 4.2). However in 2010, the use of trellis significantly affected the total and marketable yield and the total number of fruits, but not the marketable number of fruits. Marketable yield was 11% higher with the use of trellis in 2010 compared to the maxixe grown on the ground. 'Trellis' in 2010 increased total yield by 18.5% and the total number of fruits by 8.3% when compared to 'No trellis'.

There were statistical differences in fruit length and diameter with the use of trellis in 2009, but not in 2010. Fruit length was higher when grown on trellises, with 57.5 cm, and fruit diameter was greater with 37.4 cm. Individual fruit weight and spine length were not significantly affected by the use of a trellis in 2009 or 2010.

No significant differences in total yield were observed among plant spacing in 2009 (Table 4.2). For marketable yield and total and marketable number of fruits, there were significant differences among plant spacing in 2009 (Table 4.2 and Figs. 4.1, 4.2).

Table 4.2 Total and marketable fruit yields, total and marketable number of fruits, and fruit characteristics of maxixe grown with the use with trellis vs. no trellis at five plants spacing at the UMass Research Farm in South Deerfield, MA in 2009 and 2010.

	Yield (*ton.ha^{-1}*)		Number of fruits (*Fruits/plant*)		Fruit Characteristics			
Treatment	Total	Marketable	Total	Marketable	Weight (*gr*)	Length (*mm*)	Diameter (*mm*)	Spines (*mm*)
			2009					
Trellises								
No Trellis	48.00	21.00	84.50	38.70	45.79	57.53	36.90	5.08
Trellis	49.00	20.10	84.60	37.00	45.53	56.56	37.37	5.52
Spacing(cm)								
15	51.31	22.39	90.79	42.04	45.53	56.56	37.23	5.51
30	48.51	21.92	84.75	39.90	45.56	57.27	37.24	5.26
45	52.71	23.32	91.45	42.24	46.14	56.96	37.05	5.50
60	45.24	18.66	79.05	34.36	45.94	57.30	37.23	5.23
75	44.31	16.79	76.63	30.61	45.17	57.00	36.87	4.96
Results of ANOVA								
Trellis (T)	NS	NS	NS	NS	NS	**	*	NS
Density (D) [Z]	NS	* L	* L	** L	NS	NS	NS	NS
T X D	NS	NS	NS	NS	NS	NS	NS	NS
			2010					
Trellises								
No Trellis	50.80	41.00	84.80	72.70	49.09	60.10	37.89	3.20
Trellis	60.20	45.70	91.80	73.40	51.67	60.53	38.11	3.42
Spacing(cm)								
15	48.51	37.31	76.60	61.54	49.93	60.13	38.08	3.38
30	57.37	45.24	95.94	80.65	50.57	60.73	38.51	3.47
45	56.44	44.78	88.96	74.02	50.56	60.11	37.90	3.32
60	59.24	46.64	92.66	77.22	49.66	60.41	37.65	3.18
75	55.97	43.84	87.44	71.95	51.17	60.18	37.85	3.19
Results of ANOVA								
Trellis (T)	*	*	*	NS	NS	NS	NS	NS
Density (D) [Y]	*Q	**Q	*Q	*Q	NS	NS	NS	NS
T X D	NS	NS	NS	NS	NS	NS	NS	NS

[Z] L represents a significant linear relation between spacing and the measured parameter.
[Y] Q represents a significant quadratic relation between spacing and the measured parameter.
[NS, *, **]Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

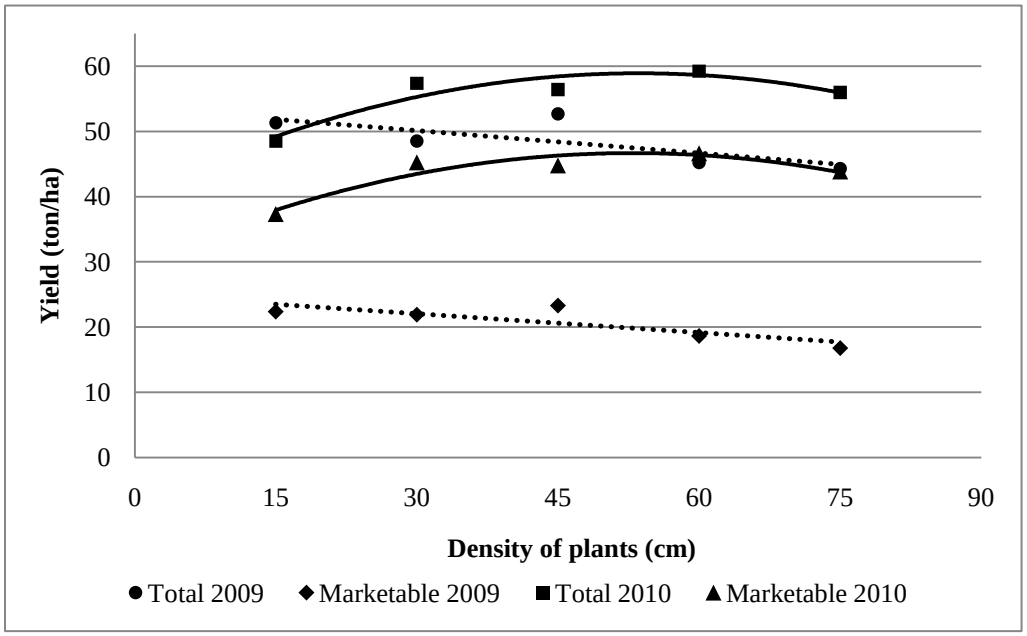

Figure 4.1 Total and marketable yield of maxixe for five spacing of plant in 2009 and 2010 at the UMass Research Farm in South Deerfield.

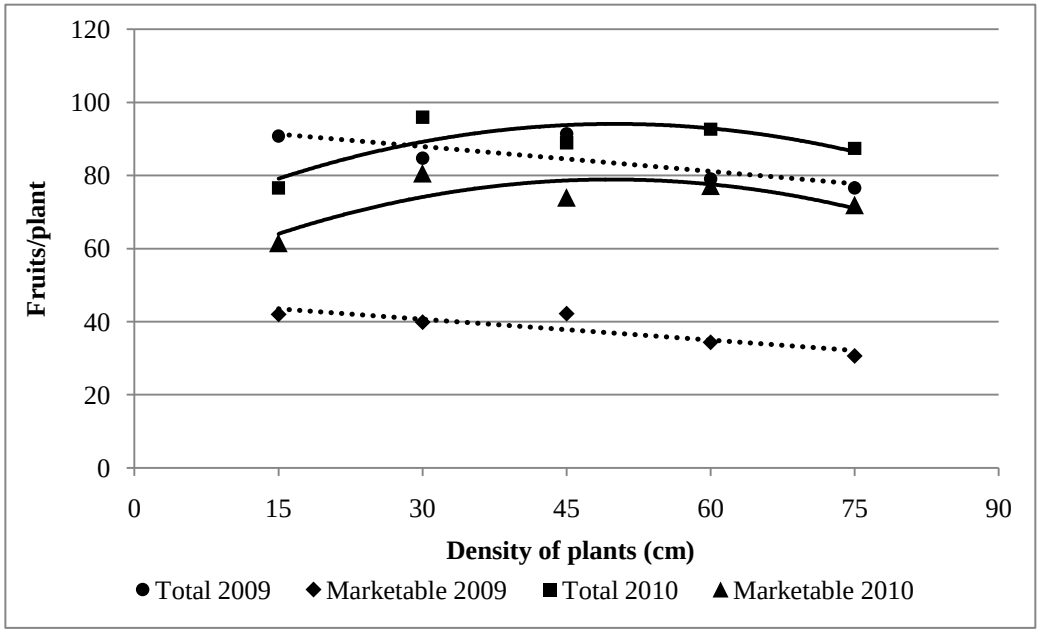

Figure 4.2 Total and marketable fruits of maxixe for five spacing of plant UMass Research Farm in South Deerfield, MA in 2009 and 2010.

There were significant differences in total and marketable yield and total and marketable number of fruits due to spacing of plants for 2010 trials. The highest total and marketable yield were produced by the spacing of '60cm' and total and marketable number of fruits were higher on the '30 cm' plant spacing in 2010 (Table 4.2). There were no differences among plant spacing for any of the fruit characteristics in both years 2009 and 2010 (Table 4.2).

Nerson (1998) reported that increasing plant spacing caused a significant increase in yield of commercial fruits of cucumbers. In the present work, results indicated the marketable yield and the marketable number of fruits were significantly different among the five spacing of plants in both 2009 and 2010. Among plant densities in 2009, approximately 42% of yield were marketable (range: 38% at '75cm'to 45% at '30cm'). In 2010, approximately 78% of yields were marketable (range: 77% at '15cm' to 79% at '30, 45 and 60 cm').

In this study, the best plant spacing for marketable yield and marketable number of fruits was '15 cm' in 2009; however, in 2010, the plant spacing that had the best marketable yield and the greater marketable number of fruits was '60 cm' and '30 cm', respectively. The experiments were conducted in two years with significantly different weather conditions in Western Massachusetts. In 2009, the period during the cultivation of maxixe was unseasonably cool, cloudy and wet, with 366 mm of rainfall and 804 accumulated growing degree days (GDD). In 2010, the summer was warm and dry, with 150 mm of rainfall and 1025 GDD, which is speculated to be a major reason for the higher yields and fruit numbers in 2010 compared to 2009.

An enterprise budget was created based on the costs and returns of maxixe for grown with and without trellis. The use of trellis support indicated that the net returns on the ‘Trellis’ are higher than ‘No trellis’ by 16% in 2009 and by 18% in 2010 (Data not shown). These results are similar to those of Shetty & Wehner (1998) with cucumber cultivars, where the authors speculate that the increase in the marketable yield on the trellis system may be due to an increase in the photosynthetic activity of plants. The higher marketable yield and the returns justify the use of trellis for production of maxixe in Massachusetts.

Table 4.3 Enterprise budget for variable costs for maxixe grown with and without trellis support, based on research at the UMass Research Farm in 2009

Labor costs (based on 1 hectare)[Y] - 2009				
	Maxixe trellis		**Maxixe no-trellis**	
	Labor HRS ($10.00/hr)	Machinery HRS ($20.00/hr)	Labor HRS ($10.00/hr)	Machinery HRS ($20.00/hr)
Take soil test	1	-	1	-
Disk harrow	1	1	1	1
Apply lime	1	1	1	1
Lay plastic and drip tape	10	10	10	10
Set up trickle system	10	-	10	-
Set transplants	27	-	27	-
Irrigate and apply fertilizer through drip	49	-	49	-
Cultivate in between plastic (5 times)	124	-	124	-
Trellis the vines	148	-	0	-
Harvest and pack	652	-	1304	-
Remove black plastic	25	-	25	-
Remove trellis net support	25	-	0	-
Seed cover crops	1	1	1	1
Total hours	**1074,45**	**13**	**1553**	**13**
Total costs	**$10.744,50**	**$260,00**	**$15.530,00**	**$260,00**

Material (based on 1 hectare)		
	Trellis	**No Trellis**
Soils test	$ 98,80	$ 98,80
Transplants[1]	$ 869,93	$ 869,93
Lime[2]	$ 61,75	$ 61,75
Trellis net support [3]	$ 8.293,37	$ -
Fertilizer through drip[4]	$ 939,37	$ 939,37
Black plastic mulch and drip tape[5]	$ 918,72	$ 918,72
Boxes[6]	$ 2.964,00	$ 2.964,00
total	**$ 14.145,94**	**$ 5.852,57**

Total costs and returns (based on 1 hectare)		
Labor costs	$ 10.744,50	$ 15.536,30
Machinery hrs	$ 271,70	$ 271,70
Material costs	$ 14.145,94	$ 5.852,57
Total costs	**$ 25.162,14**	**$ 21.660,57**
Total returns	**$ 95.629,71[7]**	**$ 82.583,10[8]**
Net (total returns – total costs)	**$ 70.467,57**	**$ 60.922,53**

[Y] Labor costs based on two people working on research experiments in 2009

[1] Based on a plant population of 36420 plants/ha (plastic 1.83 meters on center with single row of plants 15cm in the row). 100 flats of 72 at $3.52/flat

[2] $50/ton; 453.6 Kg applied

[3] Based on 22packs of trellis with 100 meters at $ 64.95, and 242 packs(with 6 wooden stakes) at $ 7.97.

[4] 12 bags of calcium nitrate (22.7 kg) at $12.63/bag; 5 bags of 20-20-20 (11.3Kg) at $ 45.75/bag

[5] Plastic and drip tape laid 1.82 meters on center – 5468 m/ha

[6] Based on 100boxes each harvest and 12 harvests, $ 1.00/box

[7] 21 metric tons @ $4.40/kg

[8] 20.1 metric tons @ $4.40/kg

Table 4.4 Enterprise budget for variable costs for maxixe grown with and without trellis support, based on research at the UMass Research Farm in 2010

Labor costs (based on 1 hectare)[Y] - 2010				
	Maxixe trellis		**Maxixe no-trellis**	
	Labor HRS ($10.00/hr)	Machinery HRS ($20.00/hr)	Labor HRS ($10.00/hr)	Machinery HRS ($20.00/hr)
Take soil test	1	-	1	-
Disk harrow	1	1	1	1
Apply lime	1	1	1	1
Lay plastic and drip tape	10	10	10	10
Set up trickle system	10	-	10	-
Set transplants	27	-	27	-
Irrigate and apply fertilizer through drip	49	-	49	-
Cultivate in between plastic (5 times)	124	-	124	-
Trellis the vines	148	-	0	-
Harvest and pack	652	-	1304	-
Remove black plastic	25	-	25	-
Remove trellis net support	25	-	0	-
Seed cover crops	1	1	1	1
Total hours	**1074,45**	**13**	**1553**	**13**
Total costs	**$10.744,50**	**$260,00**	**$15.530,00**	**$260,00**

Material (based on 1 hectare)		
	Trellis	**No Trellis**
Soils test	$ 98,80	$ 98,80
Transplants[1]	$ 869,93	$ 869,93
Lime[2]	$ 61,75	$ 61,75
Trellis net support [3]	$ 8.293,37	$ -
Fertilizer through drip[4]	$ 939,37	$ 939,37
Black plastic mulch and drip tape[5]	$ 918,72	$ 918,72
Boxes[6]	$ 2.964,00	$ 2.964,00
total	**$ 14.145,94**	**$ 5.852,57**

Total costs and returns (based on 1 hectare)		
Labor costs	$10.744,50	$ 15.536,30
Machinery hrs	$ 271,70	$ 271,70
Material costs	$ 14.145,94	$ 5.852,57
Total costs	**$ 25.162,14**	**$ 21.660,57**
Total returns	**$ 184.142,70[7]**	**$ 156.909,13[8]**
Net (total returns – total costs)	**$ 158.980,56**	**$ 135.248,56**

[Y] Labor costs based on two people working on research experiments in 2009

[1] Based on a plant population of 9107 plants/ha (plastic 1.83 meters on center with single row of plants 60cm in the row). 100 flats of 72 at $3.52/flat

[2] $50/ton; 453.6 Kg applied

[3] Based on 22 packs of trellis with 100 meters at $ 64.95, and 242 packs (with 6 wooden stakes) at $ 7.97.

[4] 12 bags of calcium nitrate (22.7 kg) at $12.63/bag; 5 bags of 20-20-20 (11.3Kg) at $ 45.75/bag

[5] Plastic and drip tape laid 1.82 meters on center – 5468 m/ha

[6] Based on 100boxes each harvest and 12 harvests, $ 1.00/box

[7] 21 metric tons @ $4.40/kg

[8] 20.1 metric tons @ $4.40/kg

4.4 References

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CONCLUSIONS

Massachusetts farmers are always interested in new markets and it can be a challenge to introduce a new crop to their rotation. It is critical that growers have a thorough understanding of the whole production system, beginning with the availability of seeds, and including all the various production practices that they must learn and implement in order to grow these crops successfully. It is also critical for the grower to understand the marketing component, including the market demand for a specific crop and the distribution system used to deliver the crops to the consumer, before starting the seed. For the Brazilian market, the strong preference for their traditional cuisine facilitates marketing strategies for maxixe in Massachusetts and the large Brazilian population in this state is a good incentive for local farmers to grow maxixe.

In many cases it is very difficult to introduce ethnic crops to traditional markets due to the unusual taste to consumers that are not from the ethnic group that uses this crop. However, there is interest in something that is "new". Maxixe has the potential to be accepted by the non-Brazilian market due to its unique shape and flavor. Promotional material, such as nutritionally-balanced recipes, point sales and information cards provide useful information for non-Brazilian costumers.

Maxixe can be grown in Massachusetts using the same cultural practices as cucumbers. In this research we found that the use of trellis made harvest easier and faster compared to when plants were left to grow on the ground. With a season similar in temperature and rainfall to 2010, the recommended plant spacing of maxixe is 60 cm in single row for greater marketable yield.

Yield results suggest that the five seed sources of maxixe are commercially viable for production in Massachusetts. However it is critical to understand the market preferences, such as size of the fruits and spines. Fruit size directly impacts the time and effort to fill a box for market. Considering the marketing system, where wholesale is based on volume of fruits and the retail sales are based on number of fruits, it is important that the farmer know what the target market wants and grow the seed source most appropriate for that market. Maxixe was sold wholesale in ½ bushel boxes with 7kg of fruits, while at farmers markets where maxixe was sold retail, it was available in bunches of 7-10 fruits each.

The maxixe fruit tends to lose its quality after five weeks of production. In addition, since there is the potential for maxixe fruit to become bitter with maturity, it is recommended that farmers have two or three plantings during the season and harvest until the fifth week of production to ensure a supply of good quality fruit throughout the season.

This work speaks to the opportunities to supply the Brazilian markets and introduce this crop to non-Brazilian markets. In order to have success with non-Brazilian markets, there needs to be similar promotional events in order to introduce maxixe successfully in the market.

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