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Luffa Sponge Gourd Production Practices for Temperate Climates

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***Abstract.* The objective of 2 years of field studies was to begin development of a luffa sponge gourd *(Luffa aegyptiaca* Mill.) production system for a cool, temperate climate by studying the effects of planting date, planting method, in-row spacing (30.5, 61, and 91 cm), and pruning techniques on yield and quality of luffa sponge gourds. High yields of mature gourds were obtained when transplants were field-set as soon as the danger of frost had past. Highest marketable yields were obtained when plants were spaced 30.5 cm apart in the row and the first four lateral shoots were removed. Plants spaced 91 cm apart produced gourds with the largest diameter, whereas plants with 30.5-cm in-row spacing produced the highest yields of gourds with bath sponge diameters (5.1-7.6 cm). Plants spaced 91 cm apart and topped at node six obtained high fiber density, strong fibers, and excellent visual appeal, but low yields. Yields were competitive with yields obtained in warmer climates.**

Luffa sponge gourds are tropical and subtropical members of the Cucurbitaceae and have been cultivated for centuries in the Middle East and India, China, Japan, and Malaysia (Porterfield, 1955). The plant is an annual vine with tendrils and large, cylindrica pepo (berry) fruit that are edible when young (Okusanya et al., 1981). The mature, dry fruit consists of a hard shell surrounding a stiff, dense network of cellulose fibers (sponge), adapted for support and dispersal of hundreds of flat, smooth, black seeds (Shah et al., 1980).

Using luffa sponges for personal hygiene and household cleaning is common in many countries. In the United States, the demand for luffa sponge products for skin care is increasing. Currently, most luffa sponge gourds are produced in tropical or semitropical environments such as Taiwan, Korea, El Salvador, Guatemala, and Colombia (Davis and DeCourley, 1993). Wholesale prices of $0.40 to $0.50 per sponge (Davis and DeCourley, 1993; D. Brinker, personal communication) coupled with the rising demand for luffa products and a desire for new, high-value crops have stimulated interest among some North American growers.

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Ample information on growing luffa sponge gourds is available for home gardeners (Johnson, 1984; Stephens, 1988; Whitaker, 1977), but the recommended practices are not necessarily appropriate for commercial producers. Most research relevant to commercial luffa production has been conducted in the tropical and subtropical climates of West Africa and India (Dubey, 1983; Okusanya, 1978, 1983a, 1983b; Okusanya et al., 1981, 1988; Okusanya and Lakanmi, 1985; Omini and Hossain, 1987; Singh et al., 1976). Only a few studies have been conducted in temperate climates (Bai et al., 1985; Ko et al., 1978). Okusanya (1978) suggested that the natural absence of luffa outside tropical and subtropical regions was due, in part, to poor germination at low temperatures and a need for high light intensity and temperature for optimum plant growth.

Luffa sponge gourd plants are similar in growth habit to cucumbers *(Cucumis sativus* L.). Substantial yield increases can be obtained by training cucumbers to a vertical trellis rather than growing them on the ground (Hanna et al., 1987; Russo et al., 1991). If luffa gourds contact the ground, fruit rot, discolored sponges, and misshaped gourds may result; thus, luffa plants also benefit from being trained to trellises (Porterfield, 1955; Sinnott and Bloch, 1943). Results from three on-farm tests in western North Carolina in 1989 demonstrated the benefits of using black polyethylene mulch and drip irrigation for luffa gourd production (J.M.D., unpublished).

Most luffa cultigens are monoecious. Staminate flowers develop in an inflorescence, whereas distillate flowers develop singly or in association with a staminate inflorescence (Takahashi, 1980). As with most monoecious cucurbits, the lower nodes of luffa usually bear only staminate inflorescences, followed by nodes having both staminate inflorescences and distillate flowers, which are followed by solitary distillate flowers at the uppermost nodes (Omini and Hossain, 1987). Increasing the number of distillate flowers would increase yield potential (Omini and Hossain, 1987) and hasten maturity-important factors for a tropical plant grown in a temperate climate. Two greenhouse studies in 1989 and 1990 indicated that removing the first four to six lateral shoots would hasten distillate flower development (J.M.D., unpublished). In contrast, preliminary research in Missouri indicated that most fruit is set on lateral and sublateral shoots and that pinching out the main stem encouraged early fruit set (C.D. DeCourley, personal communication).

My objective was to begin development of a luffa production system for a cool, temperate climate by studying the effects of planting date, planting method, in-row spacing, and pruning techniques on yield and quality of luffa sponge gourds.

Materials and Methods

Two studies were conducted in Fletcher, N.C., on a submountain plateau with an elevation of ≈631m at lat. 35°26'N, long. 82°34'W. This region has an average of 188 frost-free days, a mean annual daily temperature of 13C, and an average annual rainfall of 1470 mm (Byrd, 1988).

In 1989, the influence of three planting dates (29 May, 12 June, and 26 June) and two planting methods (direct seeding vs. transplanting) were examined as a factorial in a randomized complete-block design with four replications. Plots consisted of three 6-m rows spaced 1.5 m apart, center to center. Data were collected from the center rows; outer rows served as guard rows.

Seeds from high-quality luffa sponges were obtained from China through J.A. Ayers (Earth Products, Lapeer, Mich.). Transplants were produced in the greenhouse in plastic flats with 5 × 5-cm cells. Seed were soaked in water for 24 h and sown, two seeds per cell, in a soilless peat–bark mix on 28 Apr., 11 May, and 24 May. Plants were watered daily with 100 mg N/liter as 20N–4.4P–16.6K.

The experiment was conducted on a Delanco loam (fine loamy, mixed, mesic, Aquic Hapludults). Okusanya (1983b) suggested that *L. aegyptiaca* grew best in a neutral pH soil with high fertility, particularly N and P. Therefore, on 19 May, 84N–291P–134K (in $kg \cdot ha^{-1}$) and 1121 kg lime/ha (for a pH of 6.5) were broadcast-applied to the soil and incorporated. Beds were shaped to 15 cm high × 1 m wide, and a black polyethylene mulch (0.08 mm thick) and drip-irrigation tape (Ro-Drip, 46-cm emitter spacing; Roberts Irrigation, San Marcos, Calif.) were applied in a single operation. Holes were punched 46 cm apart in the polyethylene mulch using a bulb planter. On each planting date, seed (that had been soaked in water for 24 h) were sown two per hole (25 mm deep) or 4-week-old transplants were set out. A 1.5-m-tall vertical trellis system was constructed of 10 × 10-cm wood posts with a 2.5-cm-diameter steel pipe as the horizontal top wire. Individual strings were suspended over each plant to help train plants to the top of the trellis. Direct-seeded plants were thinned to one plant per hole 3 weeks after planting. The first four lateral shoots were pruned from all plants, and plants were trained to the strings as needed. A hive of honey bees was positioned near the field at first bloom. Pest problems were minimal; fungicides and insecticides registered for gourds were applied as needed for powdery mildew (*Erysiphe* spp.) and cucumber beetle [spotted, *Diabrotica undecimpunctata howardi* Barber and striped, *Acalymma vittata* (Fabricius)] control. On six occasions in July and August, 28 kg N/ha as 20N–4.4P-16.6 K was applied through the drip-irrigation system.

On 5 and 18 July, flowers and fruit on 91-cm lengths of row (about two plants) per plot were counted. A heavy frost killed the foliage on 30 Oct. On 3 Nov. all dried gourds (fruit) were harvested from the plots (first harvest). Remaining gourds were left to dry in the field until 4 Dec., when all dried gourds were harvested (second harvest). Any gourds not dry at that time were considered immature and left in the field. Dried gourds were soaked for 5–10 min until the fibrous interior (sponge) separated easily from the hardened skins. Sponges were air-dried and seeds were removed by shaking.

In 1990, three in-row spacings (30.5, 61, and 91 cm) and three pruning treatments (no pruning, removing the first four lateral shoots, and topping the main stem at node six) were examined as a factorial in a randomized complete-block design with four replications. Plots consisted of three 6-m rows spaced 1.5 m apart, center to center. Data were collected from only the center rows.

Seeds for this study were saved from gourds produced in 1989. Transplants were produced as previously described with seeds sown on 17 Apr. All cultural practices were the same as described for 1989. On 16 May, 84 kg N/ha and 257 kg each of P and K per hectare were broadcast-applied to the soil and incorporated. Soil pH was 6.5. On 1 June, 6-week-old transplants were set out. Plants were pruned and trained as required in the 6 weeks following planting. A total of 22 kg N/ha as 20N–4.4P–16.6K was applied through the drip-irrigation system on six occasions in August and September. Dried gourds were harvested on 17 Oct., 14 Nov., and 10 Dec.

A subjective evaluation system was used to compare sponges for overall fiber density, fiber strength, and visual appeal. Sections (76 mm square) were cut from the outer wall of representative gourds for analysis. Overall fiber density was rated on a scale of 1 to 5 (1 = very loose, open weave of fibers through which newspaper print could be read; 5 = very close woven fibers that allowed little light to penetrate). Sponge strength was rated on a scale of 1 to 5 and determined by holding the sponge near its center with hands ≈10cm apart and pulling and twisting: 1 = crumbled easily, 2 = did not crumble but could be pulled apart, 3 = took some effort to pull apart, 4 = was very difficult to pull apart, and 5 = could not be pulled apart. Visual appeal was rated on a scale of 1 to 5 (1 = poor with loose, broken, uneven fibers; 3 = good with fairly close woven, even fibers; 5 = excellent with close woven, even fibers and a smooth finish). Data were analyzed by an analysis of variance and protected least significant difference (MSTAT-C, Michigan State Univ.).

Results and Discussion

In 1989, using transplants resulted in a better plant stand than did direct-seeded plants (data not shown). Regardless of planting date, 99% to 100% of the transplants survived. In contrast, the highest stand with direct-seeding was 74%, obtained at the 29 May seeding. Direct seeding on 12 and 26 June resulted in plant stands of 68% and 63%, respectively. These germination rates are similar to those reported in a study by Okusanya (1978) in which the highest germination rates (70% to 72%) were obtained when luffa seeds were buried 10–25 mm deep in the soil and exposed to alternating temperatures of 21 and 31C.

Only a few of the 29 May and 12 June transplants had flowered by 8 July (e.g., 29 May transplants had an average of 0.9 pistillate flowers and 0.3 staminate inflorescences). Contrary to reports in which pistillate flowers did not develop on the lower portion of the plant (Omini and Hossain, 1987; Takahashi et al., 1980), in this study, there were a few pistillate flowers (one or two per plot) present on the lower plant nodes (nodes 5 and 6; data not shown). By 18 July, flowers and fruit were present on all plants that had been transplanted, but only on direct-seeded plants that were sown on 29 May (Table 1). The largest number of fruit was present on plants transplanted on the two earliest planting dates.

Dried gourds harvested immediately after the first killing frost were the highest quality because they were mature before they started to dry. For the first harvest, transplants produced 2.8 times more gourds than direct-seeded plants (Table 2). Delayed planting resulted in low first harvest yields. For the total harvest (first and second harvests), yields from transplants were 1.2 times higher than those from direct-seeded plants. Plants set on the first planting date provided higher total yields than those set on the last date. Thus, a growing season of 188 days is too short to produce luffs from seed. To produce high yields of mature gourds in a short growing season, transplants must be set in the field as soon as all danger of frost is past.

Sponge size is important to luffs product manufacturers and determines what products

Table 1. Influence of planting date and planting method on sex expression of flowers and number of fruit of luffa sponge gourds.[z]

Planting date	Planting method[w]	Staminate[y]	Pistillate[x]	Fruit
		No./91 cm of row[v]		
29 May	T	7.8	0.3	6.5
12 June	T	4.8	1.8	4.0
26 June	T	0	0.3	0.8
29 May	D	0.3	1.5	2.8
12 June	D	0	0	0
26 June	D	0	0	0
$LSD_{0.05}$ for interaction		2.6	1.5	NS
Significance				
Planting method		**	NS	**
Planting date		**	NS	**
Interaction		**	*	NS

[z]Data taken on 18 July.
[y]Inflorescences.
[x]Solitary flowers.
[w]T = transplant; D = direct seed.
[v]Due to intertwining of vines, this is about two plants.
NS, *, **Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

Table 2. Influence of planting date and planting method on first harvest, total yield, and size of luffa sponge gourds.

Main effect	No. gourds/ha (1000s) First harvest	Total harvest	Avg gourd size (cm)[z] Length	Diam
Planting method				
Transplant	33.5	82.5	35.9	8.1
Direct seed	12.1	68.0	35.5	7.6
Planting date				
29 May	33.8	82.6	36.6	8.3
12 June	21.9	74.4	35.7	7.8
26 June	12.6	68.8	34.8	7.4
$LSD_{0.05}$	7.5	7.1	NS	0.1
Significance				
Planting method	**	**	NS	**
Planting date	**	**	NS	**
Interaction	NS	NS	NS	NS

[z]From total harvest.
NS, *, **Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

can be made from a particular sponge. Neither planting date nor planting method had any effect on average sponge length (Table 2); 62% of sponges were 30.5–45.7 cm long, and <5% were <15.2 cm long. Average sponge diameter, however, was greater for sponges from transplants than direct-seeded plants and from the earliest planting date. Large-diameter sponges can be split open longitudinally and flattened into sheets for manufacturing mitts, pads, and washcloths. Of the sponges from the first planting date, >50% were in the large-diameter (7.7–10.2 cm) category, regardless of planting method (Table 3). By the third planting date, only 39% or 31% of sponges from transplanted plants or direct-seeded plants, respectively, fit that category. Luffa sponges sold as bath sponges are commonly 15–30 cm long and 5.1–7.6 cm in diameter. In contrast to the large-diameter sponges, the percentage of sponges that fit the bath-sponge diameter category increased with later planting dates.

Table 3. Influence of planting date and planting method on diameter of luffa sponge gourds.

Planting date	Planting method[z]	Percent total yield: Gourd diam (cm) 5.1–7.6	7.7–10.2
29 May	T	32	53
12 June	T	38	54
26 June	T	53	39
29 May	D	35	56
12 June	D	57	32
26 June	D	57	31
$LSD_{0.05}$[y]		10	13
Significance			
Planting date		**	*
Planting method		**	**
Interaction		*	*

[z]T = transplant; D = direct seed.
[y]For interaction.
*,**Significant at $P \leq 0.05$ and 0.01, respectively.

Ko et al. (1978) reported that gourd yields increased as in-row spacing decreased (Table 4). The closest in-row spacing (30.5 cm) resulted in the highest yields for two of the three harvests and the total season harvest. Yields obtained in this study with the 61-cm in-row spacing were ≈1.25 times greater than those reported by Ko et al. (1978) for a 60-cm in-row spacing.

Pruning three to four lateral shoots from the base of staked, determinate tomatoes (*Lycopersicon esculentum* Mill.) increased earliness but decreased total yields compared to not pruning (Davis and Estes, 1993). For luffa, neither pruning lateral shoots nor topping the main stem had any significant effect on yields on any of the three harvest dates (Table 4). For the total season, however, no pruning produced more gourds than topping at node 6.

Some gourds were badly deformed or curved, or the sponge was discolored. Those gourds were classified as culls and discarded; the remaining gourds were classified as marketable (Table 5). There was a spacing × pruning interaction for both percent culls and marketable yield. When the main stem was topped at node 6 or the plants were not pruned, percentage of culls was high at the 30.5-cm in-row spacing and low at the two wider spacings. In contrast, when the first four lateral shoots were removed, percentage of culls was highest at the widest spacing. For all pruning treatments, marketable yields decreased as in-row spacing increased. This decrease, however, was most dramatic for plants with the first four laterals removed; those plants had the highest marketable yields at 30.5-cm in-row spacing and the lowest ones at 91-cm in-row spacing.

Spacing and pruning also influenced gourd size. Average gourd diameter and length increased as in-row spacing increased (Table 6). Response of gourd length to in-row spacing was similal to results reported by Ko et al. (1978). In their study, average gourd lengths obtained with 90- to 60-cm in-row spacings were 44 and 43 cm, respectively. In comparison, average gourd lengths in this study were 42.7 and 42.2 cm for 91- and 61-cm in-row spacings, respectively.

Pruning had no effect on average sponge diameter, but topping the plants produced the longest sponges (Table 6). Neither spacing nor pruning had any effect on yields of large-diameter sponges (7.7–10.2 cm). However, a higher percentage of the total yield fit this size category when plants were spaced 91 cm apart (61%) vs. when plants were spaced 30.5 cm apar (41%). In contrast, yields of bath sponges (5.1 to 7.6 cm in diameter) were highest at the closest spacing. The most useful sponges are generally 5.1–10.2 cm in diameters and are 15.2–45.7 cm long. Plants in the 30.5-cm in-row spacing produced the highest yields of sponges 5.1–7.6 cm in diameter, 15.2–30.5 cm long, and 30.6–45.7 cm long. Pruning treatment had no effect on these size categories.

Sponge quality was evaluated using characteristics important to buyers. The importance of a characteristic depends on the final use of the sponge. For example, a very dense network of fibers is needed for bath sponges, whereas a less dense network of fibers is needed for pot scrubbers. Overall fiber density and visual appeal ratings were highest with sponges from plants spaced 91 cm apart (Table 6). Fiber density was lowest for sponges from plants spaced 30.5 cm apart, and visual appeal ratings were lowest for sponges from plants spaced 61 cm apart. Topping the main stem produced sponges with the best fiber density, strength, and visual appeal ratings. In contrast, not pruning resulted in sponges with the lowest ratings for all three characteristics.

Results from this study indicate that high yields of quality luffa sponges can be produced in a cool, temperate climate if transplants are field set immediately after the danger of frost has past. High total yields were obtained by using a close in-row spacing (30.5

Table 4. Influence of in-row spacing and pruning on total yields of luffa sponge gourds.

Main effect	No. gourds/ha (1000s), Harvest: 10 Oct.	15 Nov.	10 Dec.	Total
In-row spacing (cm)				
30.5	23.5	18.1	34.2	75.8
61	16.3	17.4	26.9	60.6
91	17.1	13.0	24.3	54.4
$LSD_{0.05}$	4.2	NS	4.3	5.7
Pruning				
Topping at node 6	17.3	13.5	28.9	59.6
Removing four laterals	18.5	17.9	28.2	64.6
No pruning	21.1	17.1	28.4	66.7
$LSD_{0.05}$	NS	NS	NS	5.7
Significance				
In-row spacing	**	NS	**	**
Pruning	NS	NS	NS	*
Interaction	*	NS	NS	NS

NS,*,**Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

Table 5. Influence of in-row spacing and pruning on marketable yields and percent culls of luffa sponge gourds.

In-row spacing (cm)	Pruning	Marketable yield (no./ha, 1000s)	Culls (% total)
30.5	Topping at node 6	57.2	15
	Removing four laterals	76.9	5
	No pruning	67.9	13
61	Topping at node 6	53.6	7
	Removing four laterals	58.8	5
	No pruning	58.3	6
91	Topping at node 6	49.1	8
	Removing four laterals	43.7	13
	No pruning	56.1	6
$LSD_{0.05}$ for interaction		10.3	8
Significance			
In-row spacing		**	NS
Pruning		*	NS
Interaction		*	*

NS,*,**Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

Table 6. Influence of in-row spacing and pruning on length and diameter of luffa sponge gourds.

	Mean		No. gourds/ha (1000s)				Quality attributes		
	Diam	Length	Diam (cm)		Length (cm)		Fiber	Sponge	
Main effect	(cm)	(cm)	5.1–7.6	7.7–10.2	15.2–30.5	30.6–45.7	density[z]	Strength[y]	Appearance[x]
In-row spacing (cm)									
30.5	7.9	39.9	36.2	31.2	10.7	42.6	2.4	2.2	2.6
61	8.3	42.2	24.0	32.4	7.4	31.7	2.6	2.3	2.4
91	8.6	42.7	15.7	33.7	4.1	28.8	2.9	2.6	2.9
$LSD_{0.05}$	0.02	1.5	5.9	NS	3.0	5.8	0.4	NS	0.4
Pruning									
Topping at node 6	8.3	42.7	22.1	30.9	5.5	31.0	3.0	3.0	2.9
Removing four laterals	8.2	40.6	28.6	31.1	8.5	37.2	2.6	2.0	2.6
No pruning	8.3	41.6	25.2	35.3	8.1	34.8	2.3	2.1	2.4
$LSD_{0.05}$	NS	1.5	NS	NS	NS	NS	0.4	0.4	0.4
Significance									
In-row spacing	**	**	**	NS	**	**	*	NS	*
Pruning	NS	*	NS	NS	NS	NS	**	**	*
Interaction	NS	NS	NS	NS	NS	*	NS	NS	NS

[z]Overall fiber density rated on a scale of 1 to 5 (1 = very loose, open weave of fibers through which newspaper print could be read; 5 = very close woven fibers that allowed little light to penetrate).

[y]Sponge strength was rated on a scale of 1 to 5 (1 = crumbled easily, 2 = did not crumble but could be pulled apart, 3 = took some effort to pull apart, 4 = was very difficult to pull apart, and 5 = could not be pulled apart).

[x]Visual appeal was rated on a scale of 1 to 5 (1 = poor with loose, broken, uneven fibers; 3 = looked good with fairly close woven, even fibers; 5 = excellent with very close woven, even fibers and a smooth finish).

NS, *, **Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

cm) and by either not pruning plants or just removing the first four lateral shoots. Plants spaced 30.5 cm apart in the row with the first four lateral shoots removed produced the highest marketable yields. Plants spaced 91 cm apart in the row produced the largest diameter gourds, whereas plants with the highest yields of bath-sponge-diameter gourds (5.1–7.6 cm) were spaced 30.5 cm apart in the row. By planting at the widest spacing and topping the main stem, plants obtained high fiber density, strong fibers, and excellent visual appeal. Those treatments also, however, resulted in the lowest yields. Spacing plants 30.5 cm apart and removing the first four lateral shoots produced sponges with a medium fiber density and good visual appeal—probably suitable for bath sponges. Further studies on sponge quality, grading standards, and market needs are required.

The question remains whether luffa sponge gourds produced in North America can be competitive with the Asian and South American imports. Economics of production are not yet known and labor costs may be high, but yields appear to be favorable; the highest total yield obtained in this study was ≈77,000 gourds/ha, which is ≈1.6 times greater than the highest yield reported in a Korean study (Ko et al., 1978).

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