Effect of Sowing Dates, Temperatures on Germination, Flowering, and Yield of *Cucumis metuliferus*

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Abstract. Seed germination, growth, flowering, and yields of *Cucumis metuliferus* Mey. were examined in several seasons and conditions in the northern Negev, Israel. Germination was optimal between 20 and 35C. Germination was delayed at 12C, totally inhibited at 5C, and greatly inhibited above 35C. Salinity increased the time required for full germination. Plants sown in mid-March set fruit in mid-May and gave a higher yield of export-quality fruits than plants sown in mid-April, which set fruit normally but produced a large proportion of small (<200 g) fruits. Plants sown in June did not flower until October. *C. metuliferus* sown in a greenhouse on three dates in October and November developed very slowly during the cold months and leaves were chlorotic; however, fast growth and development resumed in the spring and high yields were eventually achieved.

Cucumis metuliferus (African horned cucumber, kiwano, melano) is endemic to the semi-arid regions of southern and central Africa, where it is eaten as a supplement by

the local population (Bruecher, 1977; Keith and Renew, 1975). The plant is a monoecious, climbing annual with staminate flowers typically appearing several days before pistillate flowers. The ellipsoid fruit is bright yellow-orange when mature and shaped like a short, stout cucumber with many blunt thorns on its surface. The mesocarp is green and consists of juicy, bland-tasting tissue. Parthenocarpic fruits are produced when temperatures are low (A.B. and S.M., unpublished). *C. metuliferus* is grown as an ornamental fruit in New Zealand, Kenya, and

Israel, and its market is expanding. Since the fruit has a long shelf life and retains its decorative appeal for many months at room temperature, it can be developed into a decorative vegetable (Joy, 1987). Moreover, if its flavor is improved it may also have potential as a new vegetable crop.

Conditions for successful germination and the effect of sowing dates on crop development were studied in a series of experiments designed to identify cultivation practices useful for economic production.

Germination. Percentage and rate of germination were examined at 8, 12, 20, 25, 35, 40, and 45C. Ten seeds were placed between two layers of wet cotton in petri dishes (85-mm diameter) in each of two dishes per treatment. The seeds used were prepared from ripe fruits grown for these experiments. After separation from the jelly, seeds were stored at room temperature for 6 months because preliminary tests indicated that aging for several months improved germination (A.B. and S.M., unpublished). Germination was scored daily by root emergence for 24 days. Germination under saline conditions (0, 20, 50, and 80 mM NaCl) was examined at 30C using the same protocol but with 15 seeds per dish.

Date of planting experiment. Seeds were sown on sandy loess at the Sha'ar Hanegev Experimental Station (northern Negev, Israel) on 15 Mar., 15 Apr., and 3 June 1988 at a density of 10,000 plants/ha. The experimental design consisted of a Latin square with three treatments. The field was divided into nine rows on raised beds, each 2 × 54 m (width/length). Three rows constituted one block and each row was partitioned into three sections 18 m long, each sown at one of the three dates. The middle row of each block was used for yield and fruit quality analyses.

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Fig. 1. Air temperature 1.5 m above the plants (A) and soil temperature at a depth of 15 cm (B) in the greenhouse, 1988/1989.

Table 1. Percentage germination of *C. metuliferus* seeds at eight temperatures and four NaCl concentrations."

Variable	Time to maximum germination (days)	Final germination (%)
Temperature (°C)		
8	∞	0
12	24	90
20	8	100
25	3	100
30	3	100
35	5	100
40	20	35
45	2	15
NaCl (mm)		
0	3	100
20	3	100
50	12	100
80	24	100

*Germination tests used 10 seeds and two replications (15 seeds at 30C for NaCl test).

Irrigation was supplied by a single drip line running down the middle of each row with 2-liter-h⁻¹ drippers spaced 0.5 m apart. The field was irrigated twice a week with amounts calculated to replenish 40% of evapotranspiration measured by a type A pan until first flower stage and 80% thereafter. Cultural measures (fertilization and disease and pest control schedules) were similar to the local practice for melons. Fertilizer cubes (3 chicken : 1 cow manure) were preplant incorporated at 2 Mg·ha⁻¹. A single harvest when almost all fruits were ripe (after color break, i.e., when skin shifts from dark green to pale yellow) was carried out 30 June and 16 Sept. for the first and second sowing dates, respectively. The plants from seeds sown in June were not harvested as they failed to produce fruit before October, when the experiment was terminated. At each harvest, a 10-m² plot was chosen in each bed and all fruits were harvested and graded as large

Fig. 2. Height of plants in the greenhouse during the first period of growth (n = 15).

(≥220 g) or small (< 200 g).

Greenhouse production. *C. metuliferus* seeds were sown in three raised beds on 27 Oct. and 16 or 26, Nov. 1988 in a polyethylene-covered greenhouse at the Sha'ar Hanegev Experimental Station. Each bed was 2 × 30 m (width/length) and was supplied with a single line of drippers delivering 2 liter·h⁻¹ and spaced 0.5 m apart. The greenhouse was divided in a randomized block design into three equal sections sown on different dates. Culture practices were the same as those used for melons grown in greenhouses in the area. Minimum and maximum air temperature and soil temperature at 0800 and 1430 HR were recorded daily (Fig. 1). The height of the main stem of five plants per replicate was measured weekly until the plants became too entangled for measurement, i.e., 4 to 5 months after emergence. Open staminate and pistillate flowers were counted weekly on the same five plants per sowing date. Fruits were harvested when ripe (at color break), and fruit yield and number were determined in a 5-m² area in each row. Fruits were graded as large (≥200 g) or small (<200 g).

Germination. In the 20 to 35C range, germination was completed (95% to 100%) in 3 to 8 days (Table 1). At 12C, germination commenced at day 16, reaching 90% on day 24; at 8C it was completely inhibited. At very high temperatures (40 and 45C), percentage germination was greatly reduced relative to the optimum range, although enough seeds germinated to indicate possible genetic variation for heat tolerance (Table 1). Up to a level of 50 mM NaCl, germination under different temperatures and salinities followed a threshold model in respect to time. At 80 mM NaCl, germination was slow, reaching 100% only after 24 days, and followed a linear regression model ($r = 0.979^{***}$, $df = 10$).

In the planting date experiment, the foli-

Fig. 3. Pattern of emergence of staminate (A) and pistillate flowers (B) as affected by sowing dates (n = 15).

age of plants sown on 15 Mar. covered the beds in ≈ 6 weeks. The first pistillate flowers were observed on 10 May, and fruits reached color break 8 weeks later. Vines of plants sown on the second date (15 Apr.) covered the beds only after 10 weeks, although here too pistillate flowers appeared after 8 weeks; fruit development was slower, and although the number of fruits per area was similar ($271 \cdot 10^3$ vs. $245 \cdot 10^3$ for the March planting), many fruits were smaller (Table 2). Incomplete pollination, the development of parthenocarpic fruits, or altered sink-source relations may be responsible for the small fruit sizes recorded under high temperatures (10-day mean maxima of 30 to 35C and minima of 18 to 23C). The plants sown on 3 June failed to grow well and by the end of the experiment in October had neither covered the beds nor flowered. The plants of the March sowing yielded >46 Mg of fruits/ha (Table 2). More than 60% of these fruits were large (≥200 g) and would command premium prices in the market (Joy, 1987). The yield for the second sowing date was 28 Mg·ha⁻¹, of which only 25% consisted of fruits classified as large; nearly half the fruits were very small and of noncommercial size (Table 2).

In the greenhouse experiment, seedlings emerged on 2 and 20 Nov., and 20 Dec., respectively, for the three sowing dates (27 Oct.; 16 and 26 Nov.). In the October sowing, plants grew well as long as air minima remained > 9C and soil minima > 15C (first 6 weeks), but when temperatures fell, growth

Table 2. Fruit size, fruit number, and yield of *C. metuliferus* at several sowing dates in the field (expt. I) or in the greenhouse (expt. II).

Experiment	Sowing date	Yield (Mg·ha ⁻¹) by size			Fruit no. (1000/ha) by size ^y		
		Large	Small	Total	Large	Small	Total
I	15 Mar.	27.9 a	18.5 a	46.4 a	107 a	138 b	245 a
I	15 Apr.	7.0 b	21.2 a	28.2 b	31 b	239 a	271 a
II	27 Oct.	35.8 b	10.6 a	46.4 b	126 b	88 a	214 a
II	16 Nov.	53.8 a	10.2 a	64.0 a	192 a	56 ab	248 a
II	26 Nov.	45.8 ab	6.2 a	52.0 ab	162 ab	38 b	200 a

^zData are means of three replications; mean separation in columns at $P = 0.05$.

^yLarge fruits ≥ 200 g; small fruits < 200 g.

and development almost ceased and leaves began to yellow and dry out. Rapid plant growth was resumed when minimum air temperatures rose $>9^{\circ}\text{C}$, and henceforth growth was rapid (Fig. 2). Plants sown in mid-November also ceased to grow and develop with the onset of low night temperatures ($< 9^{\circ}\text{C}$) in December, but, as in the earlier planting, plants recovered quickly once minimum temperatures for growth were reached. Plants sown in late November barely grew before March. Staminate flowers emerged after ≈ 110 days in the October sowing and after 100 days in the November sowings; however, because they were sown earlier, plants sown in October were the first to flower (Fig. 3 A,B).

A few pistillate flowers were produced during the winter months in plants from the October sowing (Fig. 3B), but in the November sowing they emerged only when the weather grew warmer. Total number of fruit, the percentage of marketable fruits, and yield were highest in the early November sowing (Table 3).

In conclusion, it appears that *C. metuliferus* has a high yield and high pest and disease resistance (Provvidenti and Robinson, 1974), decorative appeal, and long shelf life, which should help it carve out a lucrative market. The crop could successfully be grown in Israel, and likely similar areas, using cultural practices current for muskmelon (*C. melo* L.). However, sowing date is a critical fac-

tor, as associated environmental conditions influence emergence, growth, flowering, and fruit number and size.

The best time for sowing *C. metuliferus* in the northern Negev region was mid-March to early April. It may be worthwhile to experiment with planting seedlings prepared in a controlled greenhouse in February and the beginning of August, to enable arrival of fruit on the market at an earlier date. However, in the northern Negev, very late sowing in autumn or winter, when minimum temperatures are low, is not recommended even under plastic cover, as it results in a longer growing season.

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