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FINAL REPORT

PROJECT NO. I-597-83

Breeding and Crop Physiology of Once-Over Harvest Melons

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1988

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October, 1988

B.A.R.D.

P. O. Box 6

Bet Dagan, ISRAEL

Project No. I-597-83C

BREEDING AND CROP PHYSIOLOGY OF ONCE-OVER HARVEST MELONS

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Project's starting date: August, 1984

Type of report: Final

הספיקה והפירות
למדינת ישראל
בית-דגן

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Abstract

The primary objective of this proposal was to breed a concentrated yielding muskmelon resembling 'Galia', the most important cultivar in Israel. This objective has been achieved, with the release of the new concentrated-yield 'Qalya' set for January 1989. Testing of prototype hybrids and of 'Qalya' itself and its parents was conducted in both Israel and Florida. Total yields of 'Qalya' and 'Galia' were similar, but 'Qalya' produced 30% more fruit and its fruits were 30% smaller (a distinct advantage for export) than 'Galia'. Approximately three-fourths of the yield of 'Qalya' was concentrated in a 5-6 day harvest period and 'Qalya' produced nearly twice as many fruits as 'Galia' during their respective peak harvest periods. Soluble solids content of 'Qalya' was slightly less than that of 'Galia' (11.8% vs. 12.6%). In progeny tests, the parents of 'Qalya' were both found to be superior to their respective parents of 'Galia' in yield concentration, equal in total yield, and slightly lower in soluble solids content. Birdsnest (concentrated-yield) lines were found to have in common a low percentage of internodes on the most developed (largest) primary branch at all stages of development. However, due to high between-plant variability, it was not possible to determine the mode of inheritance. A concentrated-yield prototype of 'Qalya' responded better than 'Galia' to an increase in plant density, producing higher yields. Sucrose accumulation in 'Galia' mesocarp was found to be mediated in part by acid invertase activity.

Objectives of the Original Research Proposal

The original proposal had six objectives: (a) to continue the transfer of the birdsnest phenotype to American and Israeli cultivars, (b) to test progenies of the most advanced selections against their recurrent parents, (c) to study the inheritance of the birdsnest phenotype, (d) to design the proper agrotechniques to fit the birdsnest phenotype, using the most advanced breeding lines, (e) to examine physiological interrelationships between initial and subsequent fruit set, and (f) and to examine the physiological interrelationships between branching and concentrated fruit set. The proposal received qualified support, the stipulation being that goals (e) and (f) be dropped. Given the difficulties involved in breeding a concentrated yielding line having the highest possible soluble solids content, we later added to the research the goal of studying the physiology of sucrose accumulation in developing melon fruit. Of the five goals of the project, from a practical point of view the achievement of goal (a) with regards to a new Israeli cultivar was of the utmost importance. As discussed below, four of the five goals of this project have, by and large been achieved. Only for goal (d) has there been but partial achievement.

Achievement of Objectives

Objective a: Breeding.

The fruit on muskmelon plants do not ripen synchronously but rather over a period of several weeks, and ripe fruits quickly lose their quality if not picked and removed from the field promptly. Thus the field must be entered by workers every two to four days, usually ten times or more during the harvest season. Much labor is thus required for harvesting. Some of the largest growers in Israel have abandoned melon growing because of the labor problem at harvest.

In 1966, Israeli plant explorers sponsored by a Ford Foundation grant collected seeds of melon cultivars in Iran (Slomnicki et al. 1966). Some of these cultivars were unusual in that they had a concentrated yielding pattern. Unfortunately, they were highly susceptible to diseases and their fruits were of poor eating and keeping quality (Paris et al. 1981). In 1978, a backcross-pedigree breeding program for transfer of the concentrated yield characteristic to horticulturally desirable cultivars was initiated. B.A.R.D. support began in 1980 with a grant to our proposal no. I-130-79. The current proposal, I-597-83C, is a continuation. The program has reached the BC_3F_6 generation for the female parent of 'Galia' and the BC_6F_{10} for the male parent (early in our work it was found that concentrated yield is basically a complex, recessive trait, necessitating its incorporation into both parents of a hybrid). The

breeding has been carried to the BC_3F_3 and beyond in several American cultivars.

A concentrated yield in horticulturally desirable cultivars of melon would hold great advantages. It would simplify cultural practices, allowing for precise scheduling of irrigation, fertilization, and pest control. It would save labor, as a greater percentage of the melons would be ripe on a given harvest day, reducing the number of harvest days. And, upon development of a suitable machine, it could allow for once-over mechanical harvest. Such a machine has been developed within the framework of B.A.R.D. grant US-856-84 (the Principal Investigator is a Cooperating Investigator in that grant).

Prototype hybrids, constructed from early backcross-pedigree generation parents, were tested against 'Galia' in Israel and Florida to determine the degree of progress made. The results have been reported by us (Nerson et al. 1986; Paris et al. 1985, 1986b, 1988). In short, the results showed that these prototypes had a concentrated yield and were much improved over the Iranian material in fruit quality, but still not close to that of 'Galia'.

In 1988, the final year of the project, the most advanced hybrid (BC_3F_5 female crossed with BC_6F_8 male) was scheduled for testing at three locations in Israel and seven locations in Florida. Testing was to include field trials and semi-commercial (0.2 hectare) plots. Due to the large quantity of seed required for thorough testing, the aid of the Hazera' Seed Company was enlisted for seed production. As

it turned out, the seed produced by Hazera' contained 30% monoecious rogues. Thus, the only meaningful data that could be obtained was from the lone experiment sown from seeds produced by ourselves. The results obtained from this experiment, which were clear-cut, are summarized in Table 1. This latest hybrid has been named 'Qalya' and submitted for registration with the Israel Plant Breeder's Rights Council.

The trial was sown on 20 April at Newe Ya'ar. The field was prepared as elevated beds the previous fall, 200 cm between bed centers, each bed being 150 cm wide (ditches 50 cm wide). Superphosphate was banded and ammonium sulfate broadcast (600 kg/ha of each) the previous fall. Plots (replicates) were 5 m in length, 10m² in area. There were eight plots per cultivar, and these were arranged in a paired design. After emergence, the plants were thinned to two per 50 cm of row, to give a density of 20,000 plants per hectare, which is about optimal for 'Galia' but probably suboptimal for 'Qalya' (Paris et al. 1988). Harvesting was conducted every 2-3 days, there being ten harvests in all. Statistical analysis was by paired t-test, with ns=not significant and *, **, *** representing 5%, 1%, and 0.1% levels of significance, respectively.

Table 1. Results of trial of 'Qalya' vs. 'Galia', Newe Ya'ar, 1988.

<u>Variable</u>	<u>Qalya</u>	<u>Galia</u>	<u>t</u>	<u>P</u>
Yield (t/ha)	46.8	48.0	0.7184	ns
Fruit (thousands/ha)	43.0	32.8	7.0167	***
Fruit size (kg.)	1.09	1.47	8.4648	***
Soluble solids content	11.8	12.6	2.3592	ns
Yield in peak harvest (t/ha)	14.1	10.1	2.6232	*
Yield in 2 consecutive peak harvests (t/ha)	26.3	17.1	4.9443	**
Yield in 3 consecutive peak harvests (t/ha)	35.1	26.1	4.6113	**
Yield in 4 consecutive peak harvests (t/ha)	40.9	33.2	2.6825	*
Fruit in peak harvest (thousands/ha)	12.8	6.5	5.0583	**
Fruit in 2 consecutive peak harv. (thou/ha)	23.5	12.1	4.0403	**
Fruit in 3 consecutive peak harv. (thou/ha)	31.5	17.1	6.1913	***
Fruit in 4 consecutive peak harv. (thou/ha)	36.6	22.6	5.0760	**
Percent yield in peak harvest	30.6	21.4	2.9814	*
Percent yield in 2 consecutive peak harv.	56.7	36.3	4.2873	**
Percent yield in 3 consecutive peak harv.	75.5	55.2	3.9611	**
Percent yield in 4 consecutive peak harv.	87.6	70.6	2.7156	*
Percent fruit in peak harvest	30.1	19.9	3.0737	*
Percent fruit in 2 consecutive peak harv.	55.1	36.9	2.3765	*
Percent fruit in 3 consecutive peak harv.	73.3	52.2	4.0020	**
Percent fruit in 4 consecutive peak harv.	85.2	69.2	2.4916	*
Yield concentration index	2.07	2.65	5.4060	***
Fruit concentration index	2.12	2.85	4.6142	**
Days to peak yield	83.3	87.0	2.7815	*

From Table 1, it is seen that 'Qalya' and 'Galia' had similar yields but differed very highly significantly for yield components. 'Qalya' produced 30% more fruits and they were 30% smaller than those of 'Galia'. As smaller fruits obtain considerably higher prices per unit weight than larger fruits on the export market, this is a clear advantage to 'Qalya'. Soluble solids content of 'Qalya' was somewhat less, though insignificantly so, than that of 'Galia'. 'Qalya' produced considerably more yield and fruits than did 'Galia' in each of their respective peak harvest periods. Yield and fruit concentrations can be measured as a percentage in peak harvest (giving an estimate of recovery in a once-over harvest regime) or as an index (the lower the index the greater the concentration, giving an estimate of concentration over the entire harvest period, McCollum et al. 1987). 'Qalya' had a significantly more concentrated yield, regardless of the method of measuring concentration. 'Qalya' produced 35 t/ha of melons and approximately three-fourths of its yield, and produced nearly twice as many fruits as did 'Galia', in each of their respective peak three-consecutive harvest periods. 'Qalya' was also four days earlier in maturity than 'Galia'.

Objective b: Progeny testing.

Progeny testing of the breeding lines versus their recurrent parents was conducted throughout the proposal and the results reported (Nerson et al. 1986; Paris et al. 1986b). The latest progeny testing

was conducted in the summer of 1988 at Newe Ya'ar for the parents of 'Qalya' versus the parents of 'Galia', under exactly the same conditions as for the hybrids (above). The results are summarized in Tables 2 and 3.

The female parents (Table 2) produced similar yields which were, overall, considerably lower than those of the hybrids. The fruits of the 'Qalya' female parent were 20% smaller than those of the 'Galia' female parent, and its soluble solids content was considerably (1.7%) lower. The 'Qalya' female had more concentrated fruiting than the 'Galia' female.

The 'Galia' male outyielded the 'Qalya' male by 17% because its fruits were 40% larger (Table 3). The 'Qalya' male was four days earlier and produced 18% more fruits, and they were lower in soluble solids by nearly 1%. Yield of the 'Qalya' male were considerably more concentrated than those of the 'Galia' male. The fruits of the 'Qalya' male were considerably more netted than those of the 'Galia' male.

Overall, the results indicate that the fruiting of both 'Qalya' parents was considerably more concentrated than that of the 'Galia' parents. However, there is still the need, mainly in the female parent, to increase the soluble solids content to a level more equal to that of 'Galia'.

Table 2. Results of progeny test of female parents of Qalya and Galia

<u>Variable</u>	<u>Qalya</u>	<u>Galia</u>	<u>t</u>	<u>P</u>
Yield (t/ha)	35.4	38.2	1.604	ns
Number of fruits (thousands/ha)	31.4	28.4	1.443	ns
Fruit size (kg)	1.13	1.35	3.917	**
Soluble solids content (%)	10.9	12.6	6.178	***
Yield in peak harvest (t/ha)	10.5	9.5	0.583	ns
Yield in 2 consecutive peak harvests (t/ha)	17.9	15.1	0.910	ns
Yield in 3 consecutive peak harvests (t/ha)	25.0	23.9	0.402	ns
Yield in 4 consecutive peak harvests (t/ha)	31.1	29.0	1.429	ns
Fruit in peak harvest (thousands/ha)	9.3	6.9	1.989	ns
Fruit in 2 consecutive peak harvests (th/ha)	16.0	11.0	2.853	*
Fruit in 3 consecutive peak harvests (th/ha)	22.1	14.9	3.355	*
Fruit in 4 consecutive peak harvests (th/ha)	27.6	21.3	4.681	**
% Yield in peak harvest	28.4	25.3	0.908	ns
% Yield in 2 consecutive peak harvests	49.8	40.0	1.311	ns
% Yield in 3 consecutive peak harvests	69.6	62.4	1.208	ns
% Yield in 4 consecutive peak harvests	87.4	77.4	2.880	*
% Fruit in peak harvest	28.8	25.0	1.267	ns
% Fruit in 2 consecutive peak harvests	49.4	39.5	2.424	*
% Fruit in 3 consecutive peak harvests	70.5	61.5	1.611	ns
% Fruit in 4 consecutive peak harvests	87.8	76.6	3.004	*
Yield concentration index	2.31	2.65	2.103	ns
Fruit concentration index	2.31	2.81	3.516	**
Days to peak yield	90.9	91.4	0.360	ns

Table 3. Results of progeny test of male parents of Qalya and Galia.

<u>Variable</u>	<u>Qalya</u>	<u>Galia</u>	<u>t</u>	<u>P</u>
Yield (t/ha)	47.4	55.5	2.980	*
Fruit (thousands/ha)	57.1	48.3	2.486	*
Fruit size (kg)	0.83	1.16	9.111	***
Soluble solids (%)	10.4	11.3	4.994	**
Yield in peak harvest (t/ha)	18.9	14.0	2.523	*
Yield in 2 consecutive peak harvests (t/ha)	33.2	24.6	2.962	*
Yield in 3 consecutive peak harvests (t/ha)	38.2	35.1	0.722	ns
Yield in 4 consecutive peak harvests (t/ha)	40.8	45.1	1.281	ns
Fruit in peak harvest (thousands/ha)	22.3	12.1	6.128	***
Fruit in 2 consecutive peak harvests (th/ha)	40.0	20.9	5.628	***
Fruit in 3 consecutive peak harvests (th/ha)	46.3	30.8	4.022	**
Fruit in 4 consecutive peak harvests (th/ha)	49.3	37.8	3.117	*
% Yield in peak harvest	40.7	24.9	4.584	**
% Yield in 2 consecutive peak harvests	70.7	43.9	4.325	**
% Yield in 3 consecutive peak harvests	80.9	62.2	2.752	*
% Yield in 4 consecutive peak harvests	86.4	81.1	1.546	ns
% Fruit in peak	39.1	25.0	4.852	**
% Fruit in 2 consecutive peak harvests	69.9	43.4	5.193	**
% Fruit in 3 consecutive peak harvests	78.7	61.4	3.369	*
% Fruit in 4 consecutive peak harvests	86.1	78.3	2.089	ns
Yield concentration index	2.21	2.48	1.204	ns
Fruit concentration index	2.23	2.57	1.541	ns
Days to peak yield	81.3	84.9	3.342	*

Table 4. Results of trial of 'Galit' vs. 'Arava', Newe Ya'ar, 1988.

<u>Variable</u>	<u>Galit</u>	<u>Arava</u>	<u>t</u>	<u>P</u>
Yield (t/ha)	49.8	46.5	1.087	ns
Fruit (thousands/ha)	43.5	32.5	6.428	***
Fruit size (kg)	1.14	1.43	5.495	***
Soluble solids (%)	11.9	12.1	0.238	ns
Yield in peak harvest (t/ha)	13.5	9.7	1.607	ns
Yield in 2 consecutive peak harvests	23.5	17.2	2.602	*
Yield in 3 consecutive peak harvests	31.2	26.6	1.552	ns
Yield in 4 consecutive peak harvests	37.8	31.7	1.752	ns
Fruit in peak harvest (thousands/ha)	12.0	7.3	2.714	*
Fruit in 2 consecutive peak harvests (th/ha)	20.6	12.1	4.822	**
Fruit in 3 consecutive peak harvests (th/ha)	27.9	18.9	3.437	*
Fruit in 4 consecutive peak harvests (th/ha)	33.8	23.3	3.780	**
% Yield in peak harvest	26.8	21.8	0.955	ns
% Yield in 2 consecutive peak harvests	47.3	38.5	1.572	ns
% Yield in 3 consecutive peak harvests	63.0	58.8	0.580	ns
% Yield in 4 consecutive peak harvests	33.8	23.3	3.780	**
% Fruit in peak harvest	27.4	22.0	1.262	ns
% Fruit in 2 consecutive peak harvests	47.4	37.3	2.361	ns
% Fruit in 3 consecutive peak harvests	64.3	58.4	0.904	ns
% Fruit in 4 consecutive peak harvests	77.6	71.1	0.942	ns
Yield concentration index	2.54	2.70	0.653	ns
Fruit concentration index	2.47	3.03	1.922	ns
Days to peak yield	81.1	84.0	3.451	*

A by-product of the breeding program is the hybrid resulting from crossing the 'Qalya' male parent with a parent of the 'Arava' muskmelon hybrid. The resulting hybrid, named 'Galit', closely resembles 'Arava', but has two distinct advantages: smaller fruits and earliness (Table 4). 'Galit' is a full week earlier than 'Galia'. However, the yield of 'Galit' was not significantly more concentrated than that of 'Arava'. Thus, as expected (see above), the cross of a concentrated yielding line with a normal (non-concentrated) yielding line resulted in an F_1 that was normal (non-concentrated); concentrated yield is essentially a recessive characteristic. 'Galit' will be tested again next year and if it again performs well will thereafter be released.

Objective c: Inheritance of the birdsnest growth habit.

The birdsnest growth habit is a complex characteristic, determined mainly by short internodes and high branching tendency (Nerson et al. 1983). The inheritance of the short internodes was worked out during the previous B.A.R.D. grant and found to be conditioned by a single recessive gene, designated si-2, plus modifiers (Paris et al. 1984). In this proposal we focussed our efforts on the branching tendency, as there appeared to us to be a connection between weak apical dominance, expressed as the tendency to produce many branches, and concentrated yield. Branching was examined in both Israel and Florida at different

stages of plant development. Our results, which have been reported (Paris et al. 1986a), can be summarized as follows:

Basically, the birdsnest-type accessions were found to differ from the vine-type accessions by combining the production of relatively many primary branches with a relatively uniform primary branch development; therefore the birdsnest accessions had the lowest percentage of total internodes on the longest primary branches. This was true at all stages of development examined and at both locations. However, there was great between-plant variability, so much so that overlap occurred for all variables measured at all stages and in both locations. Thus, we have concluded that the identification of the genetic factor(s) controlling weak apical dominance in melons is not possible through the use of conventional methods.

Objective d: Cultural practices.

Our cultural practices studies were to include, first, plant density studies and then studies on amount and timing of drip irrigation and fertilization. The plant density work was conducted successfully on hybrid 'D72', a prototype of 'Qalya', in Florida and Israel in 1986 and the results reported (Paris et al. 1988). Our irrigation and fertilization work was to be conducted in 1988 with the large stock of 'Qalya' seeds raised by the seed company. But the existence of 30% rogues in this stock has rendered all of the results

meaningless. The results obtained with regard to plant density in 1986 can be summarized as follows:

The plant densities employed in Florida were 10,000, 20,000, and 30,000 plants/ha and in Israel 5000, 10,000, 20,000, and 40,000 plants per hectare. At both locations, the 'Qalya' prototype and 'Galia' produced similar total yields. Yield was not significantly affected by density in Florida, but in Israel fruit number and yield increased as the density increased. Fruit size decreased with increased planting density. The 'Qalya' prototype produced a more concentrated yield than did 'Galia' at both locations. Concentration was not appreciably affected by density. The greatest production during the peak harvest period, 21.6 and 28.9 t/ha, in Florida and Israel, respectively, was obtained with the 'Qalya' prototype-20,000 plants/ha in Florida and with the 'Qalya' prototype-40,000 plants/ha in Israel. The 'Qalya' prototype responded more favorably than did 'Galia' to increased densities. Yields were lower in Florida than in Israel, attributable to the more intensive regimes of irrigation and fertilization in Israel.

Objective e: Sucrose accumulation.

The results of this work were recently described (McCollum et al. 1988). In 'Galia' melons, reducing sugars were found to account for more than 90% of the total soluble sugars during the first 24 days past anthesis, whereas sucrose began to accumulate from 24 days past

anthesis and accounted for approximately half of the total soluble sugars at fruit abscission (fully ripe). Invertase activity in the mesocarp declined continuously from 12 days past anthesis until abscission. Acid invertase activity was negatively correlated with sucrose content. The activity of acid invertase was highest during early fruit growth, when sucrose content was lowest. Our results suggest that sucrose is the source of hexoses required for metabolism during melon fruit development and that high invertase activity prevents sucrose from accumulating. Additionally, hydrolyzation of sucrose may be needed to maintain cell osmotic pressure, this in order to accumulate water during fruit growth. During later stages of fruit development, invertase activity is apparently low enough to allow sucrose to accumulate. Sucrose synthase activity was also detected in melon mesocarp.

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Description of cooperation

The Principal Investigator spent his sabbatical year at the Cooperating Institution and conducted there observations on branching and a plant density experiment. D.J. Cantliffe, Cooperating Investigator, was his host. Semi-commercial plots of the new Israeli cultivar 'Qalya' were planted throughout the state Florida. Results of the various experiments have been summarized by the investigators, and several cooperative publications have resulted.

Benefit to agriculture

The main product of this research is the 'Qalya' concentrated-yield hybrid. The concentrated yield is expected to simplify cultural practices and in so doing increase the quality of the fruit. Concentrated yield would also reduce the cost to the grower for hired help to pick the fruits. Mechanization of the harvest is a real possibility, as has been shown elsewhere (B.A.R.D. Project US-856-84). As the fruits of 'Qalya' are also smaller than 'Galia', it would make possible the growing of melons for export under conditions where 'Galia' fruits are too large and therefore not profitable. The value in monetary terms of 'Qalya' are difficult to estimate, and are dependent on market factors which are not under our control. At present, there appears to be a big opening for growing 'Qalya' under open-field conditions, especially in the summer months,

in Israel. Muskmelons in general, and 'Qalya' in particular, have the potential to become important in Florida as well.

A by-product of this research, the 'Galit' hybrid, also appears to have commercial potential. This is based on its smaller fruits and earlier maturity than 'Arava'. 'Galit' is generally very early for a good-quality hybrid, and it would appear to be adapted to the 'Arava' region of Israel. Its earliness may also give it value for the eastern U.S.

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