Table 1. Effect of NAA on fruit length, diameter, weight, volume, pulp to seed ratio, total soluble solids (TSS), and moisture content of 'Zahdi' date palm during *khalal, rutab,* and *tamar* stages.[z]

Stage NAA (ppm)	Length (cm)	Diam (cm)	Weight (g)	Volume (cc)	Pulp: seed ratio	Total soluble solids (%)	Moisture (%)
Khalal							
0	3.5	2.4	11.8	11.0	8.1	39.1	57.4
10	3.5	2.6	11.9	11.7	8.2	34.8	68.5
20	3.6	2.6	11.9	12.0	8.6	37.6	66.1
40	4.1	2.8	16.3	17.1	11.9	27.8	69.8
60	4.1	2.8	16.9	17.6	13.4	37.8	65.1
LSD 5%	0.1	0.1	0.5	0.5	1.7	10.4	9.2
Rutab							
0	3.3	2.2	8.9	9.2	8.2	77.6	30.2
10	3.4	2.3	9.5	9.7	8.7	75.1	43.1
20	3.4	2.3	11.1	10.5	9.3	70.8	38.6
40	3.6	2.5	12.3	14.1	10.6	72.4	40.8
60	3.6	2.5	12.4	14.7	11.5	71.9	38.4
LSD 5%	0.1	0.2	1.6	0.5	1.7	14.7	9.8
Tamar							
0	3.3	2.2	8.8	9.1	8.6	79.8	20.9
10	3.3	2.2	9.1	9.4	8.8	75.5	27.0
20	3.3	2.2	9.1	10.3	9.3	75.0	31.3
40	3.6	2.4	11.9	13.8	10.5	79.0	37.2
60	3.6	2.5	12.2	14.0	10.6	78.0	39.4
LSD 5%	0.1	0.1	1.1	1.5	1.7	5.8	4.9

[z]Mean of 5 replications, 20 fruits in each replicate.

local fresh consumption.

Fruit size, quality, and ripening of 'Zahdi' date palm may be improved by applying NAA at 40 and 60 ppm. Concentrations of 20 ppm or less are inadequate.

Literature Cited

1. Al-Ani, B.A., N.D. Benjamin, H.R. Shabana, and I.S. Saadawi. 1976. Effect of some growth regulators on cell number of fruit of date palm (*Phoenix dactylifera* L.) cv. Sayer (in Arabic). Baghdad Palm & Date Research Center Tech. Bul. 2/1976.
2. Benjamin, N.D., K.S. Jawad, H.R. Shabana, and H.D. Al-Agidi. 1973. Physico-chemical changes of ripening and determination of the depressed period of development in date fruit. II. Chemical changes in Zahdi and Sayer cultivars (in Arabic). *Baghdad Palm & Date Research Center Tech. Bul.* 10/1973.
3. ________, H.R. Shabana, B.A. Al-Ani, M.A. Clor, K.S. Jawad, and A.M.H. Shaibani. 1975. Effect of some growth regulators on the depressed period of development and physico-chemical changes during different stages of ripening of date fruit. I. Chemical changes (soluble solids, sugars) and moisture content in fruit of Zahdi and Sayer cultivars (in Arabic). *Baghdad Palm & Date Research Center Tech. Bul.* 1/1975.
4. Khosnaw, K.M., M.B. Al-Asead, H.R. Shabana, W.F. Al-Tai, and H.K. Al-Agidi. 1975. Some artificial auxins effects on the quality of date palm fruits. Third Intern. Palm & Date Conference, Baghdad.
5. Nixon, R.W. 1959. Effects of gibberellin on fruit stalks and fruit of date palm. Annu. Rpt. Date Growers Inst. 36:5-7.
6. Shabana, H.R., K.S. Jawad, N.D. Benjamin, and B.A. Al-Ani. 1974. Physico-chemical changes during different stages of ripening and determination of the depressed period of development in date fruit. I. Physical changes in Zahdi and Sayer cultivars (in Arabic). *Baghdad Palm & Date Research Center Tech. Bul.* 1/1974.
7. ________, ________, ________, and ________. 1976. Effect of some growth regulators at depressed period of development on the physical properties of Zahdi and Sayer cultivars (in Arabic). *Baghdad Palm & Date Research Center Tech. Bul.* 3/1976.
8. Sharples, G.C. and R.H. Hilgeman. 1950. Effect of hormone spray application upon the development and ripening of date fruit. Annu. Rpt. Date Growers Inst. 29: 14.

HortScience 15(6):725–727. 1980.

Respiration and Ethylene Production of the Developing 'Kerman' Pistachio Fruit[1]

Arazdordi Toumadje, Julian C. Crane, and Adel A. Kader
Department of Pomology, University of California, Davis, CA 95616

Additional index words. nuts, maturation

Abstract. **Respiration rate of whole 'Kerman' pistachio (*Pistacia vera* L.) fruit increased progressively during seed growth and development and gradually declined after the completion of seed growth. Blank (seedless) fruit, on the other hand, respired at a constant rate which was 5 to 6 times lower than that of fruit with seeds. There was no indication of a climacteric peak in respiration of fruit with seeds. Ethylene evolution from seeded fruit was not significantly different from that of blank fruit. Constant low levels of ethylene were maintained throughout the period of shell and hull dehiscence, as well as fruit maturation, indicating that this hormone is probably not involved in those processes.**

A respiration and ethylene evolution study was started in 1978 as part of a research project to modify rate of maturation of the pistachio nut. Initial respiration measurements of immature fruit, using the method developed by Claypool and Keefer (4), showed large variations among replicate samples collected on the same date from the same tree. Both seed abortion (2) and to a minor extent parthenocarpy (5) contribute to a relatively high incidence of blank nuts (without kernels) in 'Kerman', although they do not abscise from the trees but remain until harvest. Fruit with no kernels developing in them are identical externally to those with kernels until shortly before maturity when the epidermis of seeded fruit assumes a milky appearance. Unequal numbers of blank fruit in the replications were eventually determined to be responsible for variation in rate of respiration from one replication to another (Fig. 1). The higher the percentage of blank nuts in a sample, the lower was the respiration rate. Fruit in which kernels were developing exhibited respiration rates 4 to 5 times higher than that of blank fruit. These data were derived from samples that were separated by floatation in water.

We found, in 1979, that the use of light was a more convenient, rapid, and accurate method of separating blank from seeded fruit. A cardboard box was used to enclose the light and reflector portion of a reading lamp. A hole slightly smaller than the size of a pistachio fruit was cut in the side of the box directly opposite the light source. By placing the fruit one at a time over the hole, blanks were identified as they transmitted more light than fruit with kernels. Accurate identification of blanks, however, was not attainable until the kernels had reached about 75% of their ultimate size.

[1]Received for publication May 9, 1980.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-08-31 via Open Access. This is an open access article distributed under the CC BY-NC-ND license (https://creativecommons.org/licenses/by-nc-nd/4.0/). https://creativecommons.org/licenses/by-nc-nd/4.0/

Sampling of 'Kerman' fruit from trees at the Wolfskill Experimental Orchards, Winters, California began on June 29, 1979 and continued at weekly intervals until just before harvest on September 6. This is the period during which kernel growth and development take place within the fruit (6,7). Three replicate samples of 100 g each were placed in 400-ml wide-mouth Mason jars connected to a Claypool-Keefer (4) respirometer. A flow rate of 50 ml of air/min was maintained at 20°C for 5 hr. Air from the jars was bubbled for 15 min through the colorimeter tubes filled with bicarbonate solution containing bromthymol blue. A Bausch and Lomb Spectronic 20 spectrophotometer was used to determine light transmission at 615 nm from which CO_2 output was calculated (8).

A 10-ml sample of the atmosphere in each jar was injected into a Carle 211 analytical gas chromatograph equipped with a flame ionization detector for ethylene determination.

The pericarp of the pistachio fruit, a drupe, rapidly enlarges and reaches about ultimate size generally 30 days after anthesis, i.e. the first of April (6,7). The ovule, supported by a curved funiculus that occupies a small portion of the locule, remains dormant until the end of June when it enlarges rapidly and fills the locule during July. Respiration rate of the fruit increased as seed growth and development was initiated the last of June in the present study (Fig. 2). From a low of 36 ml CO_2/kg-hr on June 29, rate of respiration increased rapidly, as seed size increased, to a maximum of 125 ml CO_2/kg-hr on Aug 3. The rate gradually declined after seed growth was completed. There was no indication of a climacteric peak of respiration that is associated with ripening of many fruits, including some drupes (1).

Accurate separation of blank fruit from those with developing kernels was not possible until July 27. Respiration rate of blanks varied slightly between 23 and 27 ml CO_2/kg-hr throughout the sampling period (Fig. 2). Had it been possible to select with certainty blank fruit from the samples collected prior to July 27, it seems likely that their respiration rates would have been similar to those sampled on and following that date. Respiration rates of fruit with kernels shown in Fig. 2 prior to July 27 may be somewhat low because of uncertainty as to number of blanks included. It is clear, however, that fruit with kernels respire at rates 5 to 6 times higher than those without kernels. It is assumed that this is a direct result of seed growth and development, although an effect of the seed upon the pericarp in stimulating its respiration is a possibility.

There was no significant difference in ethylene evolution between blank fruits and those with kernels, both never exceeding the realtively low level of .44 µl/kg-hr (Fig. 2). These data indicate that the pericarp of the pistachio fruit is solely responsible for ethylene synthesis. Ethylene evolution was at a constant level throughout the period of seed growth and development and subsequent fruit maturation, hence it apparently is not involved in shell (endocarp) and hull (exocarp and mesocarp) dehiscence nor in maturation and ripening, as it is in many other fruits (3).

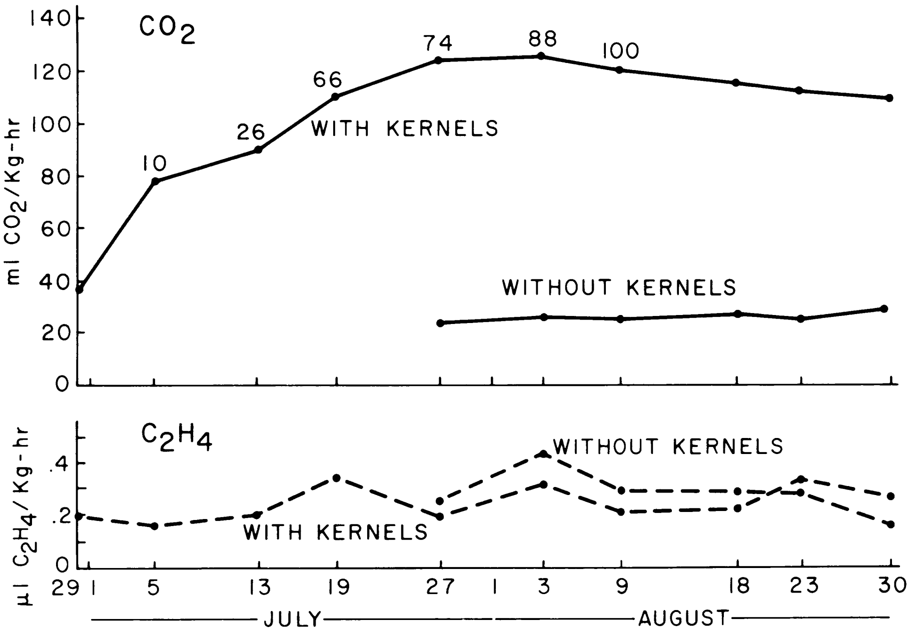

Fig. 2. Comparative rates of respiration and ethylene evolution of pistachio fruit with and without kernels. Numbers on respiration curve indicate percent kernal growth of ultimate size.

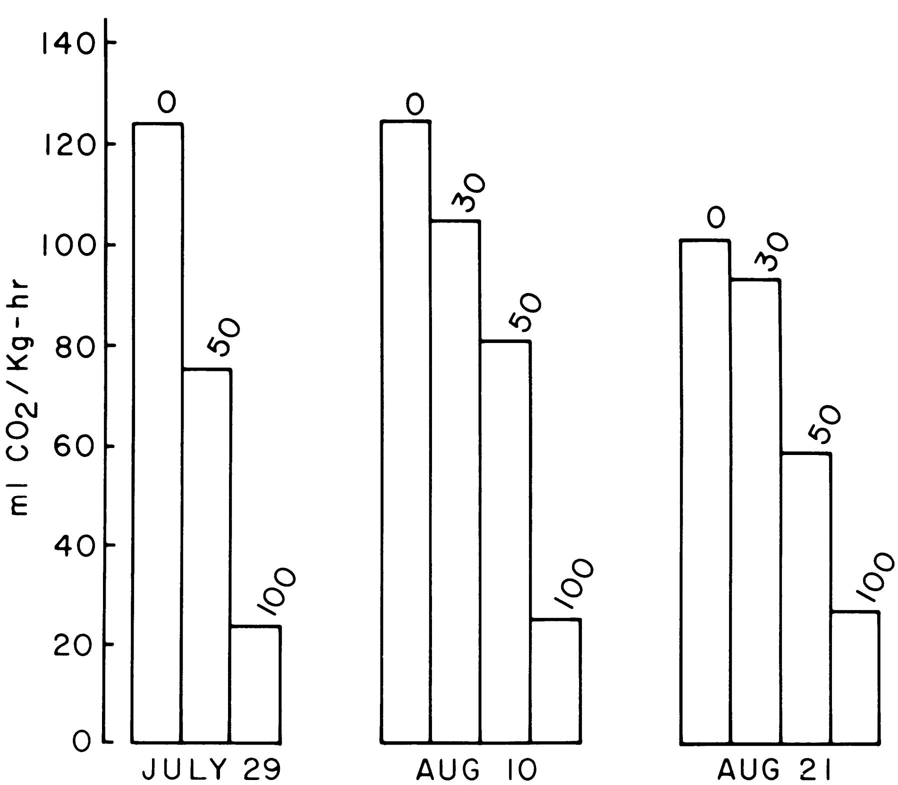

Fig. 1. Relationship between percentage of blank pistachio fruit in a sample (numbers above bars) and rate of respiration as determined on 3 dates during the latter period of nut development.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-08-31 via Open Access. This is an open access article distributed under the CC BY-NC-ND license (https://creativecommons.org/licenses/by-nc-nd/4.0/). https://creativecommons.org/licenses/by-nc-nd/4.0/

Literature Cited

1. Biale, J. B. 1960. Respiration of fruits. p. 536-592. *In* W. Rubland (ed.) Handbuch der pflanzenphysiologie, Vol. XII, Part 2 Springer, Berlin.
2. Bradley, M. V. and J. C. Crane. 1975. Abnormalities in seed development in *Pistachio vera* L. *J. Amer Soc. Hort. Sci.* 100:461-464.
3. Burg, S. P. and E. A. Burg. 1969. Role of ethylene in fruit ripening. *Plant Physiol.* 37:179-189.
4. Claypool, L. L. and R. M. Keefer. 1942. A colorimetric method for CO_2 determination in respiration studies. *Proc. Amer. Soc. Hort. Sci.* 40:177-186.
5. Crane, J. C. 1975. The role of seed abortion and parthenocarpy in the production of blank pistachio nuts as affected by rootstock. *J. Amer. Soc. Hort. Sci.* 100:267-270.
6. ________ and I. Al-Shalan. 1974. Physical and chemical changes associated with growth of the pistachio nut. *J. Amer. Soc. Hort. Sci.* 99:87-89.
7. ________, M. V. Bradley, and M. M. Nelson. 1971. Growth of seeded and seedless pistachio nuts. *J. Amer. Soc. Hort. Sci.* 96:78-80.
8. Pratt, H. K. and D. B. Mendoza, Jr. 1979. Colorimetric determination of carbon dioxide for respiration studies. *HortScience* 14:175-176.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-08-31 via Open Access. This is an open access article distributed under the CC BY-NC-ND license (https://creativecommons.org/licenses/by-nc-nd/4.0/). https://creativecommons.org/licenses/by-nc-nd/4.0/

HortScience 15(6):727–728. 1980.

Increase of Piñon Nut Size by Basal Pruning[1]

J. M. Montano, J. T. Fisher, and R. E. Gomez[2]
New Mexico State University, Las Cruces, NM 88003

Additional index words. Pinus edulis, edible nuts

Abstract. **Basal pruning of piñon pine (*Pinus edulis* Engelm.) stems to a 1.5 m. height markedly increased nut size and percent full nuts but not percent kernel (weight of kernel/weight of nut × 100).**

Piñon pine occurs upon about 23 million ha in the "Four Corner" states of New Mexico, Colorado, Utah and Arizona (1). A principal species in piñon-juniper woodlands, piñon provides multiple products including fuel wood, Christmas trees and edible nuts (3). The value of these products continues to rise, especially fuel wood. Past reference to piñon-juniper woodlands as "non-commercial" has been justly criticized (4) and many scientists are concerned with imprudent woodland removal. Coordination of operations to optimize multiple product outputs has been recommended (3) and there is a growing interest in simple methods that can be imposed over large areas to increase amounts and values of products. The purpose of this study was to evaluate basal pruning as a technique for stimulating nut production.

Yields of piñon nuts have been estimated at 336 kg per ha. Nuts are rich in protein, fat, and carbohydrates and (2, 6) and retail for $10 per kg. Commercial exploitation and marketing are highly unorganized since crops are erratic and little is known about production processes that might stabilize yields.

It may be possible to artificially stimulate nut production through insect control or cultural practices such as irrigation, fertilization or pruning. Fertilization (5, 7), especially with nitrogen and irrigation have stimulated seed production in tree improvement seed orchards. Branch pruning, widely used in horticultural crops, increased ovulate cone production in slash pine (9) but has received limited application in forestry. We are unaware of attempts to stimulate cone production through basal pruning on piñon, although this has been prescribed for reduction of disease and insect injury (8).

Piñon trees are usually scattered and widely spaced in orchard-like, multiaged stands. Nut bearing may begin at about 25 years, but does not become reliably abundant until 75 to 100 years. Cones are generally borne laterally in the axil of a scale leaf near branch tips.

Ovulate cone primordia can be seen in winter buds in September and emerge from buds the following May or June when pollination occurs. Cone enlargement ceases in late August, resumes in May and is completed by July. Cones are mature in September and seeds begin to fall in October marking the end of a seed development process lasting more than two years.

In this study, basal branches of 70 to 80-year old piñon were pruned up to 1.5 m (Fig. 1) in October to determine pruning effects on seed development. Ovulate primordia development was completed in September prior to pruning. The study included 10 randomly selected pruned trees paired with 10 adjacent control trees. The study was conducted in northern New Mexico on a site with a gently to moderate southwest slope and deep clay loam soil.

Nuts were harvested 2 years following treatment and were air-dried at 20°C for 15 days. Three 50-g samples were taken from nuts collected from pruned and control trees to determine the size and number. Fifty-nut samples were taken to determine the percentage of nuts containing kernels. Percent kernel (weight of kernel/weight of nut × 100) was calculated from this data. Data were analyzed according to Students *t*-test for paired observations.

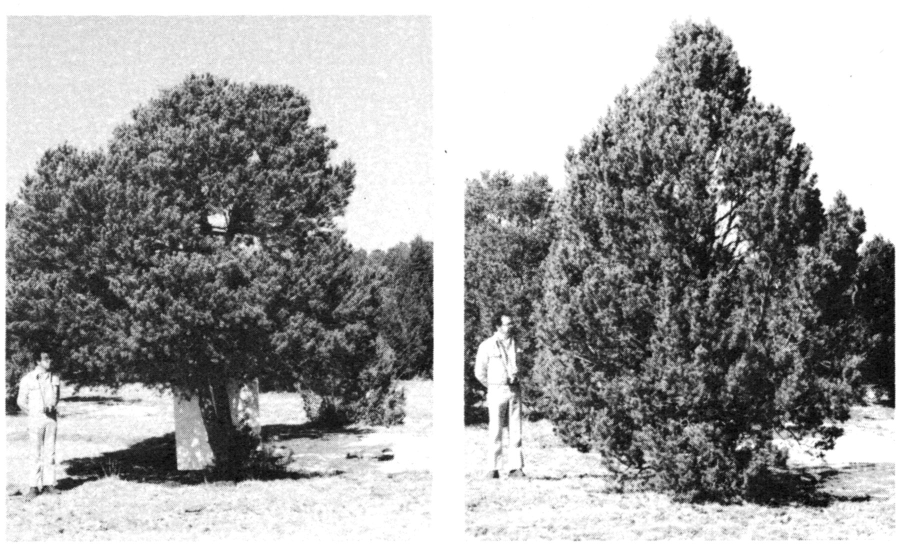

Fig. 1. Basal pruned (left) and unpruned (right) trees of piñon pine.

[1]Received for publication September 6, 1977. Journal article 633, Agricultural Experiment Station, New Mexico State University.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.

[2]Respectively, Research Specialist, Assistant Professor of Forest Ecology, and Extension Horticulturist, Department of Horticulture.