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Use of Climatic Data to Identify Potential Sites in the United States for Growing Papaver bracteatum as a Pharmaceutical Crop

R.E. Neild
University of Nebraska-Lincoln

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R. E. NEILD

Center of Agricultural Meteorology and Climatology, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, Lincoln, NE 68583

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ABSTRACT

A procedure utilizing maps in the National Climatic Atlas was used to survey the United States to find areas for domesticating *Papaver bracteatum,* a wild poppy from the Trans-Caucasus. This poppy has unique properties which make it a possible heroinless source of codeine. Climatic conditions similar to the native habitat and requirements of *Papaver bracteatum* can be found in areas of western Utah, northern Nevada, southern Idaho, eastern Washington and Oregon, northeastern California and southwestern Wyoming. A detailed climatic analysis was made to evaluate more specific locations within this large area. A site near Medford, Oregon was selected as best suited for developing modern cultural procedures and improving strains to successfully grow crops of *Papaver bracteatum.*

1. Introduction

Papaver somniferum, the opium poppy, is one of the most famous, and infamous, plants used by man. No other species paradoxically both relieves and causes so much suffering. Its pharmaceutical derivatives, morphine and codeine, which are refined and administered under government license, are powerful pain relievers. Its illicit derivatives, opium and heroin, directly destroy the lives of addicts. Clandestine operations involved in producing and distributing these drugs victimize innocent society with crime and corruption, as well.

Law enforcement procedures have had limited success in controlling the production, distribution and use of illicit drugs; the problem is worldwide. Among international programs involving agriculture in efforts to curb drug abuse are:

1) Attempts to find alternative crops that are economically competitive with opium poppies so that poor farmers in developing nations will not produce opium beyond government allotments for pharmaceutical needs.

2) Programs to develop irrigation and instruction for Bedouins and other wandering nomads so as to induce them to resettle in agricultural villages, stop their caravan trade and thereby sever one link in the complex opium distribution system.

3) Aerial surveillance to locate small hidden illegal poppy fields so they may be sprayed and destroyed by herbicides.

The use of agricultural climatology to find suitable locations in the United States for domesticating wild poppy, *Papaver bracteatum,* is reported here.

2. *Papaver bracteatum*

The discovery of populations of wild poppies, *Papaver bracteatum,* with high concentrations of an alkaloid called thebaine in mountainous regions of northwestern Iran by pharmacists Sharghi and Lalezari (1968) created interest in their use as a heroinless source of codeine. In contrast to *Papaver somniferum,* a widely grown annual plant from which opium can be readily extracted and converted into heroin, the thebaine in *Papaver bracteatum* cannot be directly used by addicts and requires sophisticated equipment and processes available only to legitimate pharmaceutical companies for converting it into codeine. Additionally, *Papaver bracteatum* is a perennial that produces large, showy, and easily recognizable red blossoms. It requires two seasons from first planting before it can be harvested and, unlike the quick-growing (4-month cycle) opium poppy, would be difficult to hide and less easily moved from place to place.

Because of these unique features, certain pharmaceutical firms, the American Medical Association, and government agencies became interested in *Papaver bracteatum* in the 1970s as a possible domestic crop to relieve a developing shortage of codeine in the United States. Success with this crop would provide more stable supplies than exist for the opium-based narcotic drugs from other countries (Rody, 1976).

Early attempts to grow sufficient quantities for analysis and testing of *Papaver bracteatum* from seeds collected in Iran were disappointing (Cheng, 1972; Stratmeyer, 1974). It became obvious that, if *Papaver bracteatum* were to be successfully grown in the United States, more information was needed about the plant's climatic requirements in order to find sites that were similar to its native habitat.

An annotated bibliography containing references to 2000 articles on opium and other poppy species and special English translations of selected foreign language articles at the National Agricultural Library has been prepared to "serve many concerned citizens and scientists in the campaign to curb drug abuse in the United States" (Duke et al., 1973). Most of the published scientific articles are on the opium poppy. The few references to *Papaver bracteatum* are on its taxonomy and aklaloids and no information is given on its life cycle or environmental requirements.

However, there are several articles in popular horticultural and gardening magazines pertaining to the life cycle, and gardening problems with *Papaver orientale,* a closely related perennial commonly grown as an ornamental (Curtis, 1945a, 1945b, 1947, 1950; Knapp, 1945; Lorenz, 1945, 1947; and Pike, 1946). *Papaver orientale* and *Papaver bracteatum* are native to the same region (Bailey, 1913; Goldblatt, 1974). The wide range of color in different varieties of the "oriental" poppy were developed from crosses between *Papaver orientale* and *Papaver bracteatum* (Curtis, 1945). The following description of the life cycle and climatic requirements for *Papaver bracteatum* is based on information in the popular articles on "oriental" poppies, a discussion of earlier attempts to grow *Papaver bracteatum* at different locations in the United States (Stratmeyer, 1974), and an analysis of climatological data from locations in its native habitat.

3. Growing cycle and climatic requirements

"Oriental" poppies (*Papaver bracteatum*) are hardy, long-lived herbaceous perennials that grow to a height of 2½–4 ft. These poppies grow readily from seeds, which are usually best planted in the autumn. As established plants, they overwinter as a rosette of leaves that arise from large fleshy roots in the early autumn after 9 to 11 weeks of midsummer dormancy. The leaf growth resumes in the spring. Increasing temperatures and longer days simulate flower bud development, June flowering, and production of capsules and seed. The leaves undergo senescence and die shortly after the capsule matures. The crown then becomes dormant and retreats below the soil surface. This completes the growing cycle, which then begins anew as crown dormancy is broken accompanied by new leaf growth as the result of cooler temperatures in the autumn.

Cool moist conditions favor plant growth in the spring and the production of large 5–7 in. flowers. These flowers are produced atop of tall, relatively fragile stems. Poppies accumulate alkaloids in their capsules until about 6 weeks after flowering. Information on capsule formation of "oriental" poppies is not available. The following are inferences concerning this important stage of development from studies of the opium poppy (Bunting, 1963).

The capsule, or poppy fruit, increases very rapidly in size following flowering. The ripe capsule readily absorbs and loses moisture in relation to changes in ambient humidity. If warm, dry conditions prevail during ripening, the alkaloid content of the capsule is highest when the moisture content is lowest. During wet seasons more than half of the alkaloid content in the capsule may be lost by the time the moisture content is a minimum. There can be marked year-to-year variation in the maximum alkaloid accumulation in the capsules. The critical periods, favorable and unfavorable factors in the life cycle of *Papaver bracteatum* for midlatitude locations, are presented in Table 1.

4. Survey and rating procedure

An agroclimatic survey procedure for *Papaver bracteatum* was developed based on 1) The plant characteristics and requirements previously discussed; 2) climatological data from Erivan and Tblisi in the Caucasus region of the U.S.S.R. and from Erzurum, Sivas, and Van in eastern Turkey (Meteorological Office, 1966); and 3) conferences with personnel in the Special Products Division, Mallinckrodt Chemical Works. This six-step procedure was used to identify areas in the United States that are climatically analogous to the native habitat of *Papaver bracteatum* and to eliminate from consideration those regions with conditions that may adversely affect its production. Maps in the Cli-

TABLE 1. Critical periods, favorable and unfavorable factors in the life cycle of *Papaver bracteatum*.

Critical period	Favorable factors	Unfavorable factors
Active fall growth to winter inactivity (15 Sep–1 Dec)	Cool weather with well-distributed rain	Abnormally warm weather, prolonged dry periods, early severe freeze
Winter inactivity (1 Dec–15 Mar)	Continuously cool, cold	Erratically cold and warm
Active spring growth to flowering (15 Mar–1 Jun)	Cool weather with well-distributed rainfall	Excessively hot (above 90°F) weather or prolonged dry spells.
Blossom-to-capsule maturation and senescence (Jun–15 Jul)	Warm, sunny, calm, dry weather	Wet, cloudy, humid weather, hail, high winds
Summer dormancy (15 Jul–15 Sep)	Warm, dry weather	Cool, humid weather or prolonged wet spells

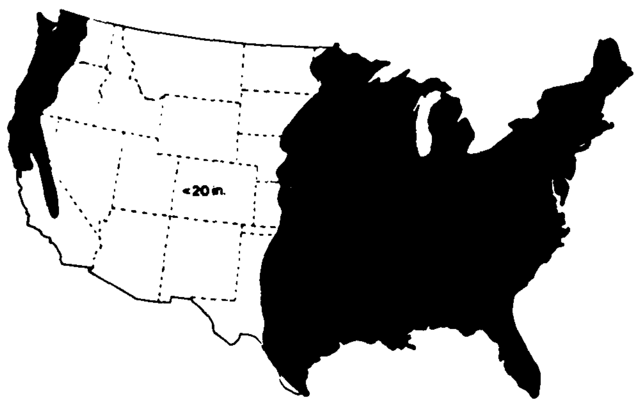

fig. 1 ANNUAL PRECIPITATION LESS THAN 20 INCHES

fig. 2 LESS THAN 10 DAYS IN JUNE 90°F. OR HIGHER

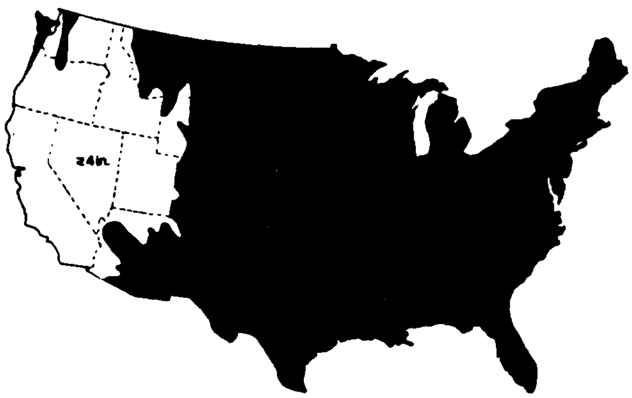

fig. 3 JUNE-AUGUST PRECIPITATION 4 INCHES OR LESS

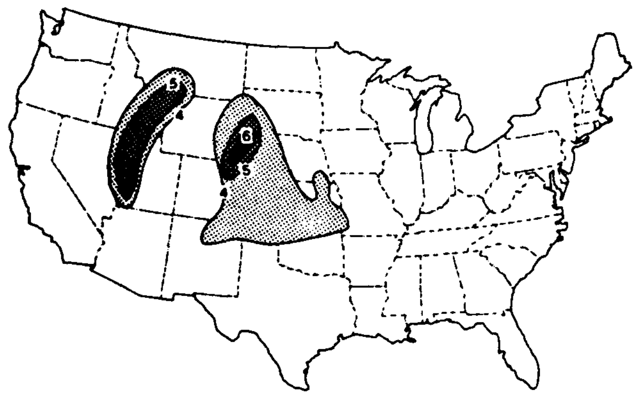

fig. 4 AVERAGE NUMBER OF DAYS WITH HAIL

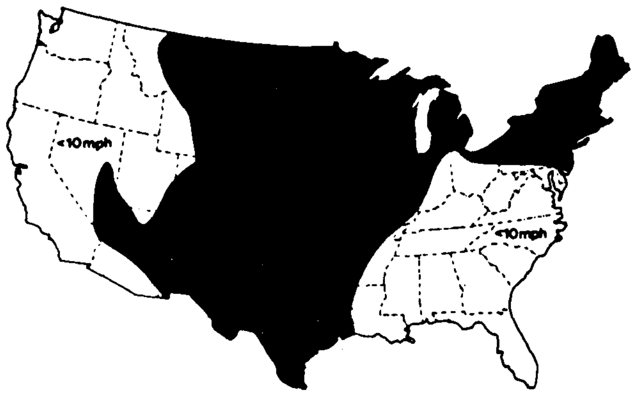

fig. 5 AVERAGE JUNE WIND SPEED LESS THAN 10 MPH

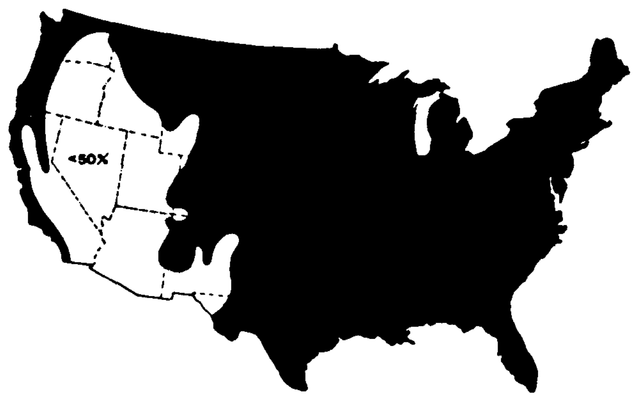

fig. 6 JULY RELATIVE HUMIDITY LESS THAN 50%

matic Atlas of the United States (1968) were used as a data source. The following criteria and maps in Figs. 1–6 illustrate the procedure used. Regions meeting these criteria are shown in the maps as unshaded areas.

Criteria 1. The area should receive between 12 and 20 in. of precipitation annually unless supplemental irrigation is available. The average annual precipitation from locations in the native habitat ranges from 12.5 inches at Erivan to 21.4 inches at Tblisi. The unshaded portion of the map in Fig. 1 shows that the 20 inch criteria is a region which lies mostly west of the 100th meridian and east of the Cascade Mountains in Washington and Oregon and Sierra Nevada Mountains in California.

Criteria 2. The area should have an average of less than 10 days in June with temperatures above 90°F. The unshaded portion of the map in Fig. 2 shows that the northern half of the United States meets this criteria.

Criteria 3. June, July and August total rainfall should average no more than 4 inches during flowering and capsule formation (1 June–15 July), and during summer dormancy (15 July–15 September). Figure 3 shows that only the western one-fourth of the United States meets this criteria.

Criteria 4. The region should have a low incidence of hail during the flowering and capsule formation period. The map in Fig. 4 shows the central portion of the High Plains and an area in eastern Idaho and Utah to have the highest hail frequency. However, there is a distinct difference in the hail intensity between the two regions. The storms in Idaho and Utah are relatively mild, but storms in the High Plains region could severely damage crops.

Criteria 5. The region should not be subject to high winds (>10 mph) during blossoming and capsule formation. The map in Fig. 5 shows that the western and southeastern portions of the United States experience lower wind speeds during this period.

Criteria 6. The region should have low relative humidity during the harvest period in July. The map in Fig. 6 shows the Great Basin states, eastern Washington, Oregon and California, Arizona, and southern New Mexico to have the lowest relative humidity in July.

The map in Fig. 7, which results from an "overall composite" of the maps generated in steps 1 through 6 shows an area consisting of parts of western Utah, northern Nevada, southern Idaho, eastern portions of Washington and Oregon, and small regions in northeast California and southwest Wyoming which have the most favorable climate for growing *Papaver bracteatum.*

Eight different climatic factors—(i) annual precipitation, (ii) the amount of precipitation during capsule formation and harvest, (iii) the distribution of precipitation relative to the phenomena of summer dormancy, (iv) maximum and (v) minimum temperature during the spring (March–May) growing season, (vi) maximum and (vii) minimum temperature during the autumn growing season, and (viii) the possible adverse effects of high temperature during flowering (June)—were used to evaluate the climates of specific locations in the unshaded area in Fig. 7 relative to their potential for growing *Papaver bracteatum.* Capsule formation and harvest time is a particularly sensitive period, so its ratings were given a heavier weighting than those for other factors.

The categories and associated rating values for these eight different factors are listed as items (i)–(viii) in Table 2. For example, a location with annual precipitation averaging between 14.0 and 16.9 inches would receive a rating of 8 for this category of climatological factor (i). If the average daily maximum temperature during the spring growing season (March–May) is between 54° and 58°F, this category of factors (iv) would receive a rating of 10. The highest possible score for the sum of the optimum categories of all 8 factors is 88. The climatic scores for different locations in the native habitat are shown in Table 3.

Sivas and Van, Turkey with 88 and 84, respectively, had the highest score in the region. Tblisi in Georgia, U.S.S.R. had the lowest score with 38.5.

Climatic scores were developed for weather stations representative of irrigated agricultural regions in the unshaded portions of the states of Nevada, Utah, Idaho, Oregon and Washington. The Water Atlas of the United States (Geraghtz, 1973) was used to locate the

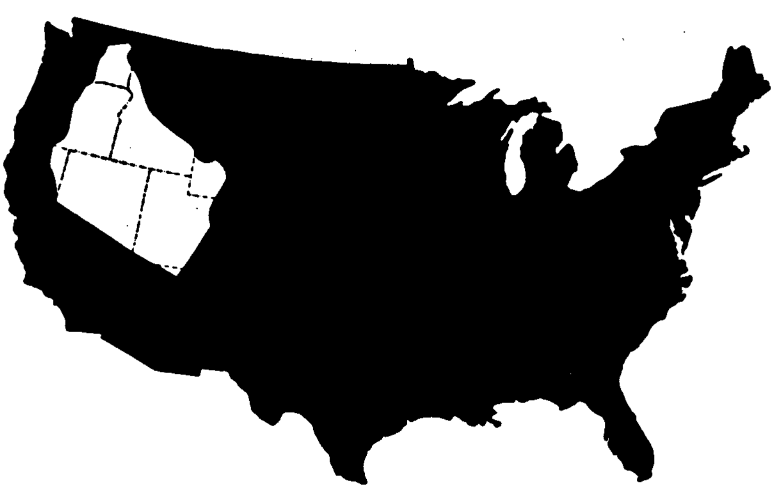

Fig. 7 Optimal climatic region for growing of P. bracteatum

TABLE 2. Rating values for climatic factors.

Precipitation (in inches)

Annual (i)	Rating	Summer (Jun–Aug) (ii)	Rating	Summer percentage (iii)	Rating
>20	2	>6.0	.5	>45	1
19.0–20.0	4	5.1–6.0	1	36–40	2
18.0–18.9	6	4.1–5.0	4	31–35	4
17.0–17.9	7	3.1–4.0	9	26–30	6
14.0–16.9	8	2.1–3.0	13	21–25	8
12.0–13.9	7	1.1–2.0	16	<20	10
10.0–11.9	6	<1.0	18		

Growing season temperatures

Spring (Mar–May) Maximum (iv)	Spring (Mar–May) Minimum (v)	Autumn (Sep–Nov) Maximum (vi)	Autumn (Sep–Nov) Minimum (vii)	Rating	Average days in June above 90°F (viii)	Rating
65–66	>40	>68	>45	2	>20	1
63–64	39	67	44	4	15–20	3
61–62	38	66	43	6	12–14	5
59–60	37	65	42	8	10–11	7
54–58	34–36	62–64	36–41	10	8–9	8
52–53	33	61	35	8	6–7	9
50–51	32	60	34	6	4–5	10
48–49	31	59	33	4	2–3	11
46–47	<30	<58	<32	2	<2	12

irrigated regions. The scores for these different regions are as follows:

Nevada—The scores for locations in irrigated regions of Nevada are presented in Table 4. They varied from 61 at La Moille to 41 at Yerrington and averaged 51 for the state.

Utah—The score (Table 5) for irrigated areas in Utah averaged 58.8. Logan had the second highest score of all the areas with 78. Logan and Ogden, Utah are climatologically and physiographically similar to Van, Turkey, which is also located adjacent to the shore of a large lake.

Idaho—The climate (Table 6) of irrigated areas along the Snake River in Idaho are favorable for *Papaver bracteatum*. Conditions at Twin Falls are the most favorable. Growing season temperatures at the higher elevations along the upper regions of the river are cooler than at Twin Falls, while those at the lower elevation near Caldwell are warmer than those at the Twin Falls area.

Oregon—The average (Table 7) climatic score for the eight different irrigated regions in Oregon was 66.1. The score ranged from 80 at Klamath Falls (highest score evaluated of the 27 U.S. locations evaluated) to 45 at Hermiston.

Washington—Washington (Table 8) had an average score of 70.3. Wenatchee, Yakima and Walla Walla ranked 4th, 7th and 10th among the 27 U.S. areas.

TABLE 3. Climatic scores for locations in the native habitat of Papaver bracteatum.

Location	(°N)	(°E)	Altitude (feet)	Climatic factor (i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	Total score
Sivas, Turkey	39.44	36.57	3888	8	18	10	10	10	10	10	12	88
Van, Turkey	38.28	43.21	5382	8	18	10	8	8	10	10	12	84
Erivan, Armenia U.S.S.R.	40.10	44.30	3248	7	16	10	2	4	4	8	11	62
Erzurum, Turkey	39.54	41.16	6401	2	4	10	4	2	8	8	12	50
Tblisi, Georgia U.S.S.R.	41.43	44.48	1325	2	0.5	4	6	2	10	2	12	38.5

TABLE 4. Climatic scores for locations in irrigated areas of Nevada.

Area	Location (°N)	(°W)	Altitude (feet)	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	Total score
La Moille	40.41	115.20	6290	7	16	10	6	—	8	2	12	61
Winnemucca	40.45	117.48	4299	4	13	6	6	4	8	4	9	54
Fallon	39.27	118.47	3965	2	18	10	—	10	—	6	7	53
Lovelock	40.11	118.24	3977	2	18	10	—	10	—	4	7	51
Minden	38.57	119.46	4700	4	18	10	2	4	—	—	9	47
Reno	39.30	119.47	4397	2	18	10	4	2	—	—	10	46
Yerrington	38.59	119.10	4375	2	18	10	—	4	—	—	7	41
										Average	51	51

TABLE 5. Climatic scores for locations in irrigated areas of Utah.

Location	(°N)	(°W)	Altitude	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	Total score
Logan	41.46	111.49	4608	8	13	10	10	8	10	8	11	78
Ogden	41.18	112.01	4280	8	13	10	6	8	8	10	9	72
Oak City	39.23	112.20	5075	6	13	10	4	10	—	10	7	60
Spanish Oaks	40.06	111.40	4620	8	13	10	4	6	4	10	7	56
Ft. Duchene	40.17	109.51	4990	2	16	8	4	—	8	—	7	45
St. George	37.00	113.34	2700	4	18	10	—	—	—	10	1	43
											Average	58.8

TABLE 6. Climatic scores for locations in irrigated areas of Idaho.

Location	°N	°W	Altitude	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	Total score
Twin Falls	42.32	114.25	3720	4	13	8	6	10	10	6	11	68
Caldwell	43.40	116.38	2420	6	13	8	2	10	8	8	9	64
Blackfoot	43.11	112.21	4503	4	13	8	8	4	6	2	11	56
											Average	62.7

TABLE 7. Climatic scores for locations in irrigated regions of Oregon.

Location	°N	°W	Altitude	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	Total score
Klamath Falls	42.13	121.47	4020	6	16	10	8	8	10	10	12	80
La Grande	45.20	118.06	2782	4	13	10	8	10	10	11	11	76
Burns	43.35	119.03	4151	6	16	10	10	6	10	4	12	74
Baker	44.47	117.50	3444	6	13	8	10	8	6	6	11	68
Bend	44.04	121.09	3599	7	13	10	8	2	10	2	12	64
Milton Freewater	45.56	118.24	1060	8	16	10	2	—	10	8	10	63
Wallowa	45.34	117.32	2935	6	9	10	8	4	10	—	6	59
Hermiston	45.49	119.17	624	4	16	10	—	6	6	10	9	45
											Average	66.1

TABLE 8. Climatic scores for locations in irrigated areas of Washington.

Location	°N	°W	Altitude	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	Total score
Wenatchee	46.34	120.36	1061	4	16	10	4	10	10	10	12	76
Yakima	47.25	120.19	800	2	16	10	4	10	10	8	11	71
Walla Walla	46.03	118.24	800	8	16	10	4	—	10	6	10	64
											Average	70.3

5. Conclusion

This agroclimatic procedure, together with a review of soil surveys and visits for more detailed observation in Oregon, led Mallinckrodt to select Medford (about 60 miles from Klamath Falls) as a site to domesticate *Papaver bracteatum*. Klamath Falls had a climatic score of 80, the highest of the various U.S. locations analyzed in this report. Modern cultural techniques have been developed, new improved strains selected and crops of *Papaver bracteatum* have been successfully grown. Agroclimatology has also been used to determine areas for growing *Papaver bracteatum* in Europe. Suitable locations in Spain have been identified, and suggested locations in Yugoslavia have been rejected. Further developments with *Papaver bracteatum* in the United States will depend on the availability of worldwide supplies of raw materials for making codeine, on national and international consideration of various government agencies and on the commercial interests of licensed pharmaceutical firms (Nystrom, personal communication, 1986).

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REFERENCES

Bailey, L. H., 1913: *The Standard Encyclopedia of Horticulture.* Vol. III. Macmillan.

Bunting, E. J., 1963: Changes in the capsule of *Papaver somniferium* between flowering and maturity. *Ann. Appl. Biol.* **51**(3), 459–471.

Cheng, P., 1972: Cultivation and analysis of *Papaver bracteatum.* M.S. thesis, School of Pharmacy, University of Mississippi.

Curtis, A. E., 1945a: How to keep oriental poppies happy. *Flower Grower,* **32,** 353.

——, 1945b: *Papaver orientale:* twenty years of breeding. *Nat. Hort. Mag.* **24,** 128–132.

——, 1947: Points to remember when planting oriental poppies. *Flower Grower,* **34,** 624.

——, 1950: The oriental poppy, a dependable perennial. *Pl. and Gard.* **6,** 89–92.

Duke, J. A., C. R. Gunn, E. E. Teppick, C. F. Reed, M. L. Salt and E. E. Terrell, 1973: *Annotated bibliography on opium and oriental poppies and related species.* A.R.S.-NE28. Report U.S. Department of Agriculture, Washington, DC.

Geraghtz, J. J., 1973: *Water Atlas of the United States.* A Water Information Center for Publications.

Golblatt, P., 1974: Biosystematic studies in *Papaver* Section Oxytone. *Ann. Missouri Botanical Garden,* **61**(2), 264–296.

Knapp, L. W., 1945: Why did my oriental poppies die? *Nat. Hort. Mag.* **24,** 128–132.

Lorenz, K. K., 1945: The 1945 oriental poppy season. *Flower Grower,* **34,** 438–439.

Meteorological Office, 1966: Tables of temperature, relative humidity and precipitation for the world. Part V: Asia. Her Majesty's Stationery Office.

Pike, A. V. 1946: *Papaver orientale. Sand. Chron.* **119,** 147.

Rody, A. F. 1976. *Papaver bracteatum:* Production and control. Department of Justice Drug Enforcement Administration Federal Register 41: No. 225.

Sharghi, N., and I. Lalezari, 1968: *Papaver bracteatum* Lindl, A highly rich source of thebaine. *Nature* **213,** 1244.

Stratmeyer, R., 1974: Special Projects Division, Mallinckrodt Chemical Works, 2nd and Mallinckrodt Streets, St. Louis, MO 63147.

U.S. Department of Commerce, 1968: *Climatic Atlas of the United States.* U.S. Government Printing Office.