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PRELIMINARY ASSESSMENT OF *CRAMBE* GERMPLASM RESOURCES[1]

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SUMMARY

Crambe abyssinica is a prospective crop as a source of erucic acid-rich seedoil. Studies on oil use, seed processing, culture, cultivar improvement, and disease resistance are in progress. Other species in the Section *Leptocrambe* also have high levels of erucic acid in their seedoils. Research on their oil composition and botanical agronomic characteristics is being initiated.

World distribution of wild species and their association with specialized pests and pathogens point to southwestern Eurasia as the possible home of the genus *Crambe*. *C. hispanica* and certain other species are distributed in the mild Mediterranean area and *C. abyssinica* in northeast Africa and Turkey.

INTRODUCTION

Seedoil charateristics of *Crambe abyssinica* have been extensively studied. The oil contains 55 to 60 percent erucic acid. Erucic acid-rich oils have many industrial applications including use in erucamide, plasticizers, lubricants, and new products like nylon 1313. Crop and utilization research in the United States is aimed at the ultimate commercialization of crambe as a new oilseed crop. *C. abyssinica* is widely adapted and has good agronomic traits (WHITE & HIGGINS, 1966), but has insufficient cold tolerance for a winter crop in the southern United States. Three cultivars, Prophet, Indy, and Meyer, have been released by the Purdue University Agricultural Experiment Station. These vary in maturity, seed size, yield, and oil content. Although cultivars are being developed and improved, genetic variation within available germplasm is narrow. Recently, seedoils of *C. filiformis*, *C. hispanica*, *C. hispanica* var. *glabrata*, and *C. kralikii* were found to contain erucic acid at levels comparable to the level of *C. abyssinica*.

TAXONOMIC CLASSIFICATION

The genus *Crambe* belonging to the Cruciferae, consists of about 30 species distributed mainly in the Mediterranean, Euro-Siberian, and Irano-Turanian regions (Fig. 1). Most species are perennial herbs; few are annuals or shrubs. The annual species are dispersed mainly in the mild Mediterranean area, with a few emigrants in eastern North Africa (Ethiopia, Tanganyika). Shrubs are exclusively of Macaronesian origin (Madeira and the Canary Islands).

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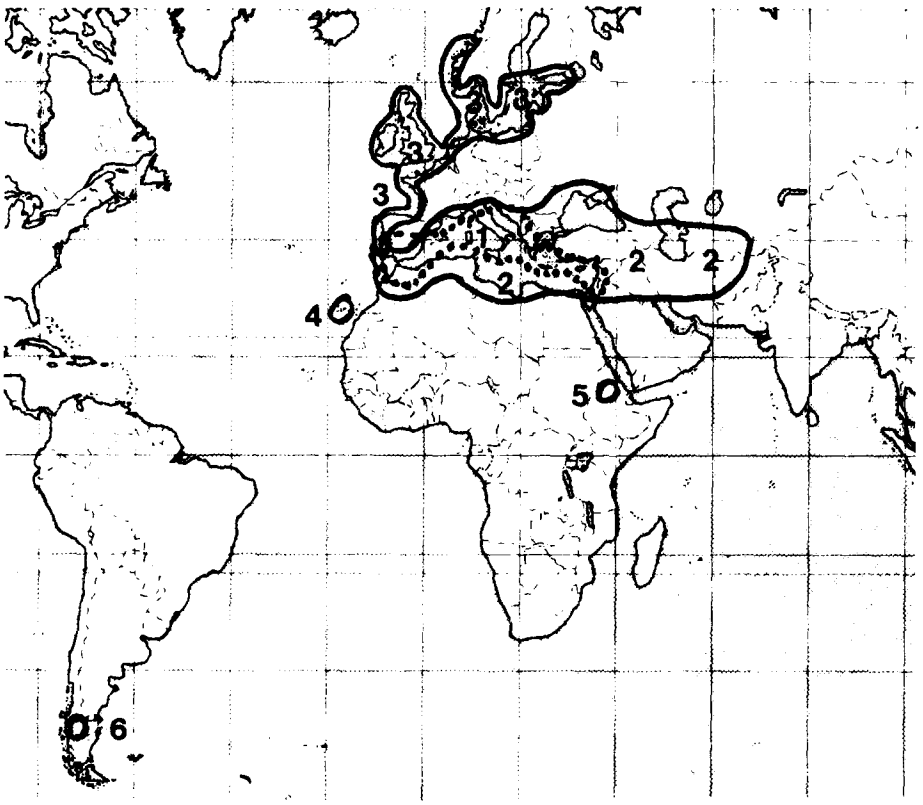

Fig. 1. World distribution of *Crambe*. Solid line (——): general distribution of the genus; dotted line (.....) distribution of *C. hispanica*. 1) *C. hispanica;* 2) Section *Sacrocrambe;* 3) *C. maritima*, Atlantic area; 4) Section *Dendrocrambe* in the Canary Islands and Madeira: 5)*C. abyssinica*, *C. sinuatolentata*, and *C. kilimandscharica* in eastern Central Africa; 6) *C. filiformis*, an outpost in Chile.

The genus has been divided into three sections: I) *Sacrocrambe* DC., perennial herbs, mainly in Eurasia; II) *Leptocrambe* DC., annual and biennials, mainly in the Mediterranean and North and Central East Africa; III) *Dendrocrambe* DC., shrubs and half-shrubs in Madeira and the Canary Islands. However, this paper details distribution for only the Section *Leptocrambe:*

1) *C. abyssinica* HOCHST. ex R. E. FRIES, (2n = 90) (Fig. 2). North African steppes, Ethiopia, Caidna, Province Tigre, Adui, Man-Shungurt, up to 1,900 m, also Cubuk Valley, Turkey (WHITE, 1975). Annual, oilseed.

2) *C. filiformis* JACQ. (2n = 30), Morocco, Algeria, south Spain, but also naturalized in Patagonia and Chile. Perennial. Economic importance unknown.

3) *C. hispanica* L. (2n = 60), Mediterranean, Syria, Palestine, North Ethiopia (Fig. 3). Annual. SCHULZ (1919) and ZOHARY (1966) cite several varieties: var. *hispanica*–in many places in Palestine; var. *major* MORIS–wild distribution unknown; var. *edentula* BOISS.– Syria at Naplouse, Palestine; and var. *glabrata* (DC.) COSSON– Morocco, Palestine, Portugal, Spain (Fig. 4).

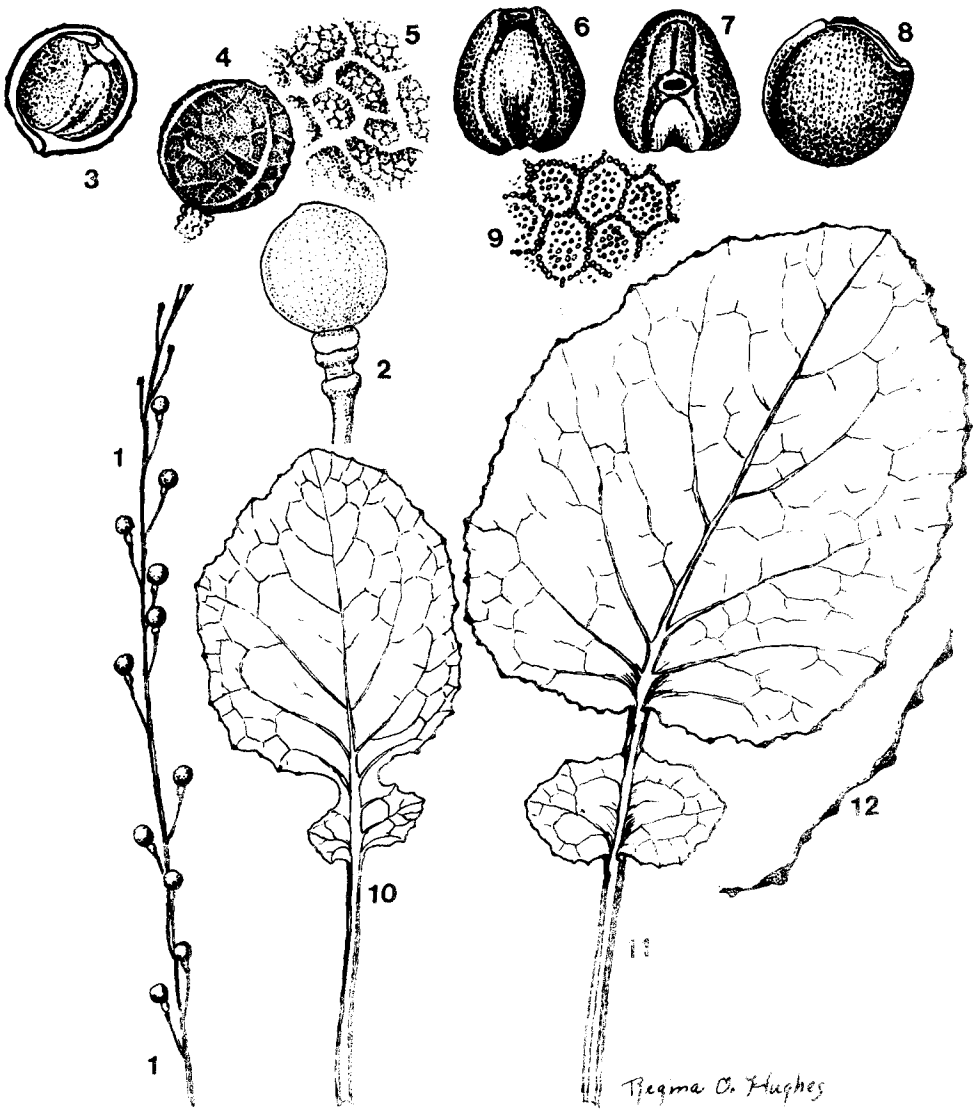

Fig. 2. *Crambe abyssinica*: 1) Branchlet with fresh fruits (X1); 2) Single fresh fruit (X5), reticulation at this stage does not show, except as faint dots; 3) A fruit dissected to show proportions of fruit and seed; 4) Mature fruit, the reticulation has become well defined; 5) Enlarged reticulation on fruit, irregular large reticulation contains a small one within; 6) Seed in face view (X9); 7) Seed in top view; 8) Seed in side view; 9) Seed coat reticulation, moniliform walls, and granular contents; 10) Basal leaf (X1); 11) Lower leaf with truncate base (X1); 12) Enlarged leaf margin, showing the blunt point of the dentation. (Original drawing made from P.I. (Plant Introduction) No. 372925).

4) *C. kilimandscharica* O.E. SCHULZ, Tanganyika Territory. Economic importance unknown.

5) *C. kralikii* COSSON (2n = 60). Southern Mediterranean area, mainly in Algeria, at Ain-Sefra 1,200–1,500 m above sea level, also Morocco. Biennial or perennial.

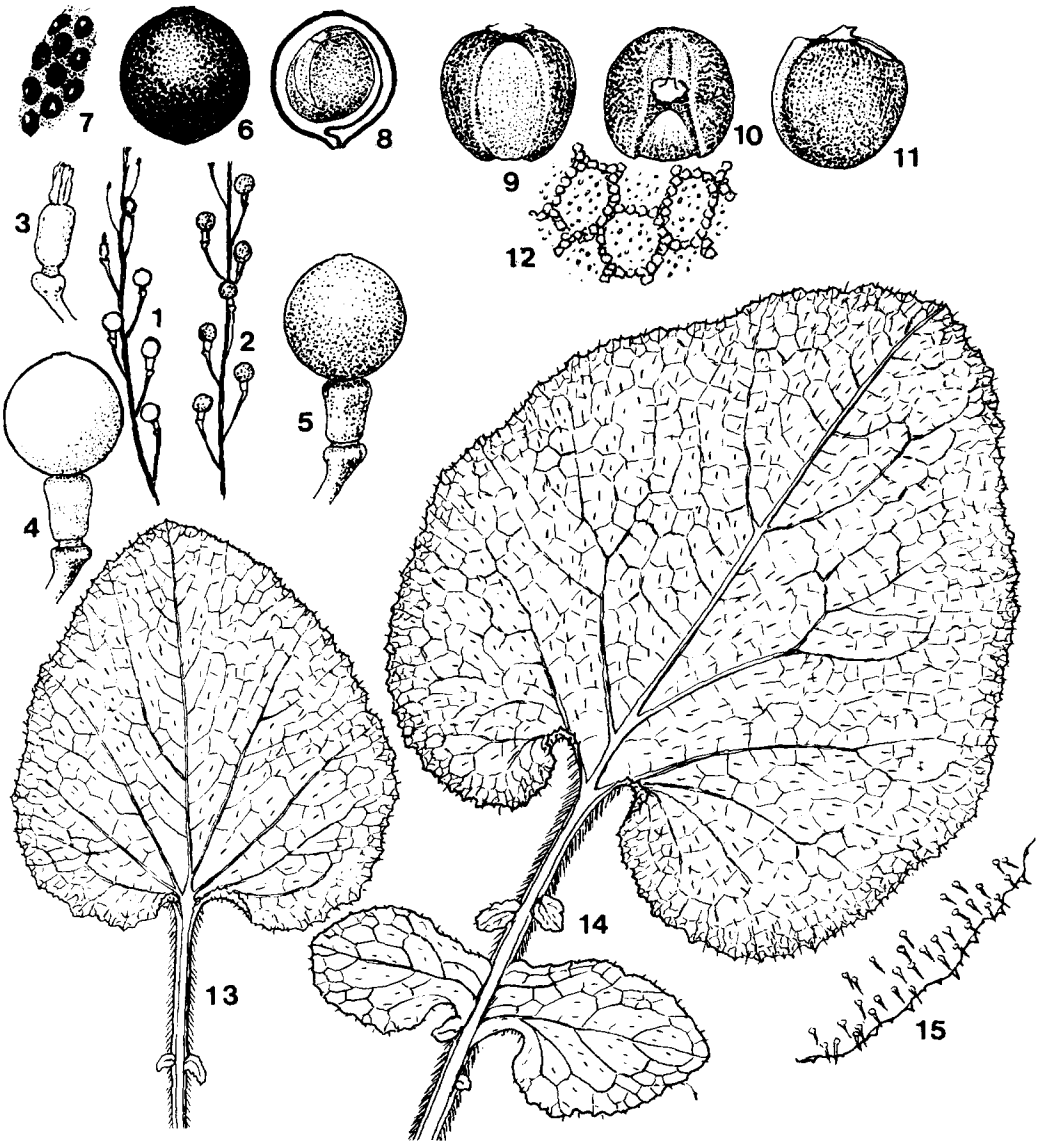

Fig. 3. *Crambe hispanica:* 1) Branchlet with fresh fruits (X1); 2) Branchlet with ripe fruits (X1); 3) Young fruit (X5); 4) Fresh fruit (X5), yellowish green, dots do not show; 5) Fruit becoming brown, with dots (X5); 6) Mature fruit (X5); 7) Enlarged surface showing black dots; 8) Dissected fruit showing seed; 9) Seed, face view (X5); 10) Seed, top view; 11) Seed, side view; 12) Enlarged seed coat showing reticulation; 13) Basal leaf (X1); 14) Lower leaf with cordate base; 15) Enlarged leaf margin showing irregular dentation. (Original drawing from P.I. 337996).

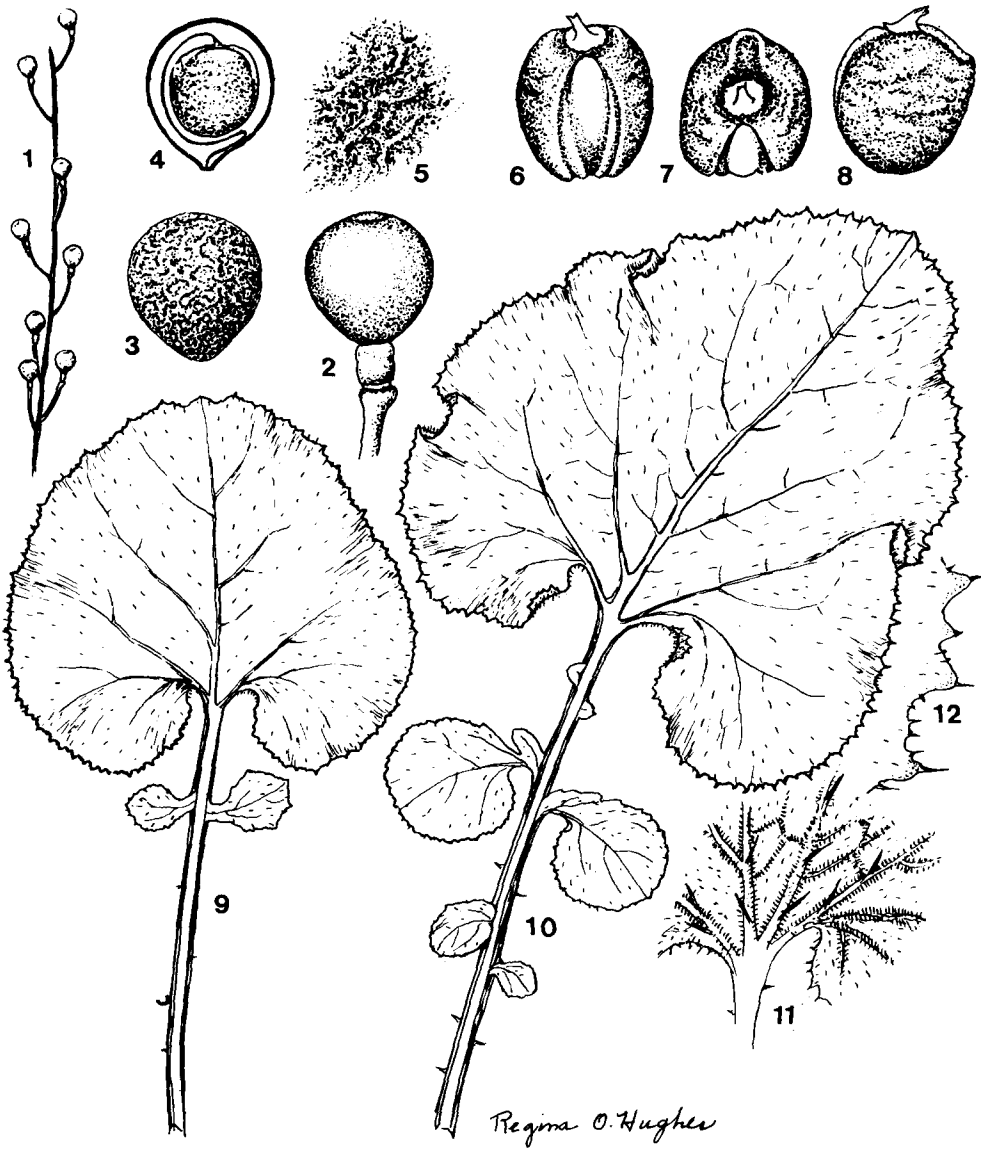

Fig. 4. *Crambe hispanica* var. *glabrata:* 1) Branchlet with fresh fruits (X1); 2) Fresh fruit (X5); 3) Mature fruit (X5); 4) Dissected fruit showing seed (X5); 5) Enlargement of the rugose, pitted fruit surface; 6) Seed, face view (X8); 7) Seed, top view (X8); 8) Seed, side view; 9) Basal, cordate leaf (X1); 10) Lower leaf with cordate base; 11) Leaf, underside, showing soft and stiff hairs; 12) Enlarged leaf margin showing short and long and stiff hairs. (Original drawing from P.I. 372928).

6) *C. sinuato-dentata* HOCHST. & SCHIMP. North African steppes, Ethiopian mountains up to 1,650 m. Economic importance unknown.

ORIGIN AND EVOLUTIONARY DISPERSION OF THE GENUS CRAMBE

Distribution of the genus *Crambe* (Fig. 1) indicates that its center of origin might have been somewhere in the southwestern part of the Eurasian continent. Preference of most species for the warm arid or semi-arid Mediterranean area, present distribution and phylogenetic history suggests that the progenitors of *Crambe* could have been members of the late Tethys flora in the northern shores of the Tethys Sea. The Mediterranean Sea is known to be a small remnant of the once extensive Tethys Sea, which separated the northern Laurasian supercontinent from the southern Gondwanaland. The huge Tethys Sea lasted from the Triassic until the late Cretaceous periods and during the Tertiary period was split into the Mediterranean Sea and Indian Ocean.

Although *Crambe* is found in South America, it is not endemic in the New World, probably because it differentiated after North America separated from Laurasia during the early Tertiary period. Consequently, *Crambe* is a relatively young genus differentiated from the Cruciferae subfamily Brassiceae after rhe drift of northern continents from each other.

Parts of Gondwanaland, such as South America, the mainland of Africa, Madagascar, Australia, and New Zealand, have no endemic *Crambe* species. The few species in Northeast Africa and South America are obviously newcomers from the Mediterranean area, probably immigrated or imported by man during early historic times.

The North and East African species *C. abyssinica, C. filiformis, C. kralikii, C. kilimandscharica*, and *C. sinuato-dentata* probably moved to Africa after Europe connected with Asia Minor at the western and eastern ends of the Mediterranean Sea. These species are closely related to *C. hispanica*, a Mediterranean species, which was carried to North Africa by man as a weed and became naturalized in Ethiopia (RICHARD, 1847; SCOTT, 1958). According to WHITE (1975), wild *C. abyssinica* occurs also in Turkey. Small populations of *C. filiformis* in Patagonia and Chile were obviously carried as weed by man from the Mediterranean area during colonial trade. *C. maritima (Sacrocrambe)* with many varieties has the most extensive dispersal on the seashores of the Baltic, North, Mediterranean, and Black Seas. A typical seashore plant, it thrives on salt-impregnated sandy soils and adapts to northern and southern climates.

CRAMBE ABYSSINICA AND C. HISPANICA

Only *C. abyssinica* has received significant attention as a potential oilseed crop. There has been little field evaluation or seed oil analysis of *C. hispanica*. The erucic acid content of the seedoils of these species is similar. They are morphologically similar, and seeds may be improperly identified. According to VASILEV (1950), most *C. hispanica* seed obtained from botanical gardens in USSR and Western Europe appeared, after testing, to be *C. abyssinica*.

According to WHITE (1975), the easiest way to distinguish betweec the species is

Table 1. Morphological characteristics and chromosome numbers of *Crambe abyssinica* and *C. hispanica*.

Characteristic	*C. abyssinica*	*C. hispanica*
Basal leaf shape	ovate	cordate
Leaf pubescence	pubescent, glabrous	pubescent, rough-haired (var. *glabrata*)
Lower fruit segment length[1]	0.3–1.0 mm	1.5–2.5 mm
Mature pericarp color	tan	dark-violet to black, tan (var. *glabrata*)
Fruit articulation	not deciduous	deciduous
Chromosome number	2n = 90	2n = 60 2n = 30 (var. *glabrata*)[2]

[1] The silicle consists of the upper (pericarp and seed, commonly referred to as the 'fruit') and lower segments.
[2] WHITE, 1975.

basal leaf shape (Table 1). The literature on *Crambe* indicates a chromosome number of 2n = 60 for *C. hispanica*, but var. *glabrata* has 2n = 30. The range of pericarp color variation of *C. hispanica* has not been observed in *C. abyssinica*. Length of the lower fruit segment is not a good distinguishing character.

DISEASES AND INSECT PESTS

Numerous pests and pathogens inhabit various wild species of *Crambe*. Several highly specialized parasitic fungi, such as rusts, powdery mildews, downy mildews, white-rusts, clubroot, leaf spots, ring spot, root rots, and bacterial rots, are reported from various countries (LEPPIK, 1973). In addition, occasional parasites and molds may cause serious losses under certain field conditions (WHITE & HIGGINS, 1966; HOLCOMB & NEWMAN, 1970; WATERWORTH & POVISH, 1970).

The origin of *Crambe* from southwestern Eurasia is further evidenced by several specialized pests and pathogens on this plant in the natural distribution areas. *Puccinia isiacae* (THUEM.) WINT. has been reported by KALYMBETOV (1956) and KOSHKELOVA (1959) on *C. kotschyana* BOISS. from southwestern Turkmenia. This rust develops its telial stage on *Phragmites communis* TRIN. [*P. australis* (CAV.) TRIN. ex STEUD], but its aecia on numerous angiosperm genera in Eurasia and North Africa. Another rust, *Aecidium crambes* MOESZ, on *C. tataria* SEBEOK has been reported from Hungary (MOESZ, 1941) and from Rumania (BONTEA, 1953).

Other specific pathogens on *Crambe*, restricted to southwestern Eurasia, are *Ascochyta crambes* BYZOVA on *C. kotschyana* (BYZOVA, 1964) from the Kazakh SSR; *Erysiphe communis* (WALLR.) LK. f. *crambae* JACZ. on *C. kotschyana* in the Kirghiz SSR and on *C. tataria* in the Ukraine (POSPELOV et al., 1957).

Virus symtoms have been observed on wild and cultivated *Crambe* in various countries. Experiments have shown *Crambe* spp. susceptible to tobacco mosaic virus (HORVATH, 1972) and *C. abyssinica* susceptible to tobacco and turnip mosaic viruses (THORNBERRY & PHILLIPPE, 1965).

Several insect infestations on *C. abyssinica* have been observed, but the damage

has been slight. False chinch bug, *Nysius ericae* (SCHILLING), flea beetles, lygus bugs, leaf hoppers, and cabbage maggots have been reported on *C. abyssinica* in the United States (WHITE & HIGGINS, 1966).

Wild species and varieties in their natural habitats have normally acquired resistance to endemic diseases and insects. However, *C. abyssinica* has remained remarkably unaffected by pests under different environments in the United States, although it is susceptible to *Alternaria*. As *Crambe* becomes an established crop with acreage increases and intensive culture, pests will undoubtedly become more troublesome. Cultivars and breeding lines will have to be screened for resistance to any serious pests as identified. Care must be exercised where new germplasm is introduced to avoid the import of pathogenic and insect pests.

FUTURE RESEARCH IMPLICATIONS

More knowledge about the genetic variability in *Crambe* germplasm resources that contain high levels of erucic acid, especially Section *Leptocrambe*, is needed to assure short and long-range continuous agronomic improvement. Except for *C. abyssinica*, little is known about agronomic and seedoil characteristics. Very little wild germplasm of *C. abyssinica* has been available for research. Specifically, variations for hardiness, maturity time, lodging resistance, seed-test weight, resistance to pests, oil and erucic acid content, and synthesis of glucosinolates in seeds must be sought. Further, germplasm resources need to be collected while still available in the wild, increased, evaluated, and preserved for long-term use. Progress is being made in assembling germplasm of several species and in assessing its characteristics.

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