CAMELINA: A USEFUL RESEARCH CROP AND A POTENTIAL OILSEED CROP

Robert G. Robinson

Station Bulletin 579-1987 (Item No. AD-SB-3275)

Minnesota Agricultural Experiment Station, University of Minnesota

CAMELINA: A USEFUL RESEARCH CROP AND A POTENTIAL OILSEED CROP

Camelina sativa (L.) Crantz has been grown in the University of Minnesota's agronomy research plots for about 30 years. Its growth and yield have been satisfactory, and no serious production problems have developed. There is no market for the plant or seed, but both current and potential uses have developed from this research.

Archaeological studies indicate that camelina is an ancient crop and that its cultivation spread from southwest to central Europe. It was probably grown for oil in the Iron Age, and the oldest find in Germany dates to about 600 B.C.[1] The crop became unimportant in the Middle Ages. However, it is still reported as a rarely grown crop on sandy soils in parts of eastern and northern Europe. Camelina species have been reported to have allelopathic effects on nearby plants. Toxic substances washed from the leaves of *Camelina alyssum* reduced flax yields by 80 percent whereas washings from other species reduced yields only 20 to 30 percent.[2] Other research showed that leaf washings from *Camelina sativa* stimulated radicle (root) growth of flax and wheat. However, the stimulation was caused by *Pseudomonas fluorescens* bacteria in the washings, because there was no effect if the bacteria were removed by filtering.[3]

The Camelina Plant

Camelina is a member of the *Cruciferae (Brassicaceae)* family, which includes mustards, rapes, canola, crambe, radish, turnip, broccoli, cabbage, rutabaga, tyfon, collards, kales, cauliflower, brussels sprouts, kohlrabi, and many weeds. The Weed Science Society of America lists camelina as a weed under the common name, falseflax.

Camelina seeds are borne in pear-shaped capsules about the size of flax bolls, and the plants superficially resemble flax (Figure 1). Camelina seeds are orange-brown, 2 mm long and 1 mm wide. The location of the radicle (root) is shown by a prominent, lengthwise ridge under the seedcoat. The cotyledons are folded together lengthwise (conduplicate) within the seedcoat. The back of one cotyledon lies against the radicle (incumbent) in contrast to other cruciferous crops where the margins of both cotyledons contact the radicle or hypocotyl in the seed (accumbent). The cotyledons emerge from the soil by elongation of the hypocotyl, and upon emergence the two cotyledons spread apart exposing the terminal bud (Figure 2). An axillary bud above each leaf may produce a branch, and the number of branches depends on the plant spacing and nutrient availability.

The plants develop hundreds of small, yellow flowers with four sepals and four petals each. The superior ovary matures into a capsule fruit nearly 1 cm long, which contains many seeds. The style of each flower matures into the point (beak) of each fruit (Figure 1).

Figure 1. Upper part of a mature camelina plant with branches and the fruits (capsules) containing the seeds.

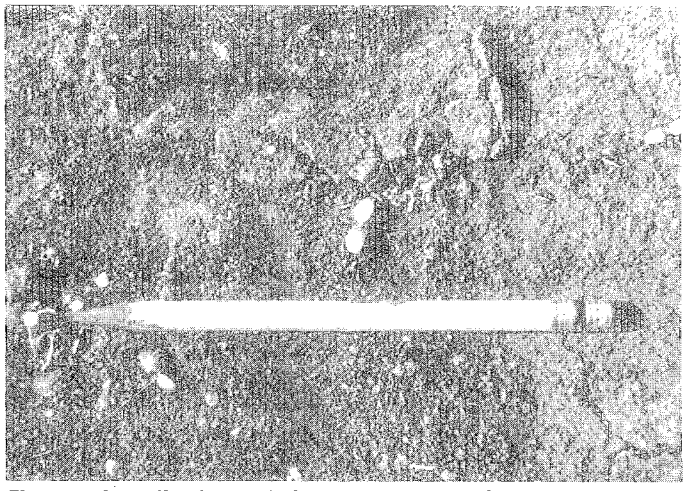

Figure 2. Camelina in cotyledon stage 18 days after planting seed.

[1]Knörzer, K.H. 1978. Evolution and spread of *Camelina sativa* s.l. Berichte der Deutschen Botanischen Gesellschaft. 91(1):187-195.
[2]Grümmer, G. 1961. The role of toxic substances in the interrelationships between higher plants. Mechanisms in biological competition. Pages 226-227. Academic Press, Inc. New York.
[3]Lovett, J.V. and H.F. Jackson. 1980. Allelopathic activity of *Camelina sativa* (L.) Crantz in relation to its phyllosphere bacteria. New Phytologist 86(3):273-277.

Performance As a Spring-sown Crop

Camelina was compared with the best varieties of other crops in the *Cruciferae* family, and it had the highest yield, least lodging, and least insect damage from 1960 through 1963 at Rosemount. Similar results were obtained in 1964 through 1967 except that *Peronospora* disease in 1966 and a hail storm at maturity in 1967 reduced camelina yield (Table 1).

Table 1. Comparison of spring-sown camelina and other oilseed *Cruciferae* at Rosemount

Crop	Variety	Yield/acre (pounds)	Oil (percent)[1]	Test weight/ bushel (pounds)	Seeds/pound (thousands)	Fresh seed germination (percent)[2]	Date mature	Lodging (percent)	Height (inches)
				1960-63					
Camelina	—	1390	32	50	567	89	7-25	29	33
Crambe	—	1360	33	24	77	51	8-7	50	46
Radish	—	870	42	52	49	92	8-20	70	41
Rape	Golden	1060	39	52	151	56	8-8	43	45
Turnip rape	Arlo	1140	38	53	252	94	7-21	48	39
Yellow mustard[3]	Ochre[4]	1210	24	55	126	89	7-28	76	42
Wild mustard[3]	—	740	31	—	216	0	8-1	56	43
LSD 5%		120							
				1964-66					
Camelina	—	900[5]	29	51	756	98	7-23	27	28
Crambe	—	880	32	25	84	84	8-3	69	41
Rape	Tanka	1030	37	52	137	81	8-6	42	42
Turnip rape	Echo	1060	36	53	239	86	7-20	49	38
Yellow mustard	Ochre[4]	1040	23	56	103	97	7-24	72	35
LSD 5%		130							
				1967					
Camelina	—	930[6]	36	50	454	—	7-28	27	33
Crambe	Indy	1330	28	26	71	—	7-28	20	39
Rape	Target	1030	44	52	113	—	8-13	44	46
Turnip rape	Echo	1020	39	53	197	—	7-28	43	37
Yellow mustard	Ochre[4]	1140	29	56	86	—	7-31	83	26
LSD 5%		190							

[1]Oven-dry basis. [2]Tested immediately after harvest. Low germination indicates seed dormancy. [3]1963 data adjusted to be comparable with 1960-63 data. [4]Ochre name licensed in 1981. [5]Yields reduced by disease in 1966. [6]Hail on July 22, 1967 shattered over 20% of the mature camelina; other species escaped this shattering loss because of immaturity or higher moisture fruits (capsules, achenes, siliques).

The oil percent column in Table 1 shows that camelina seed was 29 to 36 percent oil which was higher than that of yellow mustard but lower than that of radish, rape, or turnip rape. Camelina's test weight per bushel of at least 50 pounds was only slightly below that of rape, turnip rape, or yellow mustard. The extremely small size of camelina seed is illustrated in the sixth column of Table 1. No grain or oilseed crop grown in Minnesota, except amaranth, has such small seed.[4]

Despite its classification as a weed, camelina did not have seed dormancy, which is the major characteristic of recurring annual weeds (Table 1, column 7). This is confirmed by high dormancy (no germination) of wild mustard (a true weed) compared to 89 percent germination for camelina. Furthermore, after 30 years of camelina production on experiment station fields, volunteer camelina plants have never been a problem in crops following camelina.

Plantings at Rosemount, Waseca, Elk River, Becker, Crookston, and Roseau indicate that camelina is adapted to many of the climates and soils of Minnesota. At Crookston (Table 2) it matured in early August and yielded more seed than did radish, rape, turnip rape, yellow mustard, flax, and safflower. The trials at Crookston were conducted with standard farm machinery—planted with a grain drill and harvested by windrowing and combining. In trials on dryland sandy soil at Elk River in 1970, 1971, 1973, and 1975, camelina produced an average yield of 610 pounds of seed per acre compared to a yield of only 220 pounds for Windom flax. Compared with Westar canola at Rosemount and Roseau (Table 3), camelina was lower in yield and oil percent but 12 days earlier.

Seedbed Preparation and Planting Methods, Depths, and Rates

A firm, level seedbed is desired for small-seeded crops like camelina. Zero tillage seedbeds are usually firm and level. On tilled soil, a cultipacker or rolling basket, coil tine, flexible spike, or Meeker harrows before planting helps make firm, level seedbeds.

Camelina can be planted with grain drills, hand- or tractor-broadcast seeders, cultipacker-seeders, and some garden seed planters. With some grain drills and some garden seed planters, the rate cannot be set low enough to prevent sowing too much seed. To solve this problem, camelina seed is diluted with ground corn. Corn grain ground in a hammermill and then separated into flour and various sizes of grits in a fanning mill makes a good diluent. If a 4-pound per acre planting rate is desired, then mix 4 pounds of camelina seed with 4 pounds of corn flour and/or grits and calibrate the planter for 8 pounds per acre. Corn flour alone may be satisfactory, but some grits may be needed to prevent bridging unless there is continuous agitation. The best proportion of camelina to diluent depends on the planting mechanism.

Research on silt loam soil showed that camelina seed will emerge from a greater depth than its size suggests. Placement in the surface inch was best, but significant emergence resulted from the 2-inch depth (Table 4). This 3-year trial on a tilled

[4]Robinson, Robert G. 1986. Amaranth, quinoa, ragi, tef, and niger: tiny seeds of ancient history and modern interest. Minnesota Agric. Exp. Stn. Bull AD-SB-2949:1-24.

Table 2. Comparison of spring-sown camelina, other *Cruciferae*, flax, and safflower at Crookston, 1964-65

Crop	Variety	Yield/acre (pounds)	Oil (percent)[1]	Test weight/ bushel (pounds)	Date mature
Camelina	—	870[2]	37	52	8-6
Crambe	—	1010[2]	36	29	8-10
Radish	—	430	37	51	8-3
Rape	Tanka	580[3]	39	52	8-14
Turnip rape	Echo	440[3]	33	52	8-5
Yellow mustard	Ochre[4]	700[3]	27	55	8-3
Flax	Windom	560	36	54	8-4
Safflower	Gila	720	35	37	9-11

[1]Oven-dry basis. [2]Yields reduced in 1964 because the windrows were blown off the plots. Most of the crambe was recovered so losses of crambe were small. [3]Yields reduced in 1964 by fleabeetle feeding. [4]Name licensed in 1981.

Table 3. Comparison of spring-sown camelina, canola, oilseed rape, and yellow mustard at Rosemount and Roseau

Crop	Variety	Yield/acre (pounds) Rosemount 1979-83	Yield/acre (pounds) Roseau 1985	Oil (percent)[1]	Maturity (days)
Camelina	—	930	1610	32	91
Canola	Westar	1650[2]	2150	40	103
Rape	Reston	1250	1870	44	107
Yellow mustard	Ochre	1140	1500	25	92
LSD 5%		120	560		

[1]Oven-dry basis. [2]1983 data adjusted to be comparable with 1979-83 data.

Table 4. Planting depth and emergence of camelina on tilled, silt loam soil at Rosemount

Depth (inches)	Tillage after planting	Emergence in percent of seeds planted 1969	1970	1971
0	none	15	22	23
0	raked	47	32	—
0	spiked roller	—	—	75
1	none	63	23	83
2	none	35	4	42
3	none	2	—	—

seedbed for spring planting indicated that surface planting without any rolling or incorporating gave much lower emergence than did incorporation after planting. However with zero tillage planting, the weed or trash cover may provide a more moist and porous surface which would enhance germination and establishment of camelina (Figure 3). Camelina seed planted on the soil surface in late fall is exposed to snow cover, freezing, and thawing which may provide some covering of the seed.

Seed mortality is high (Table 4), so suggested planting rates are high enough to compensate for seed mortality. For planting in the spring, rates of 4 pounds per acre with a grain drill or 7 pounds per acre broadcast were satisfactory. For broadcast planting in the fall, 11 pounds per acre were excellent. For planting research plots in the spring, a rate of 75 seeds per square foot (5 to 6 pounds per acre) was satisfactory. For comparison, recommended rates per square foot for other small-seeded crops are: canola and yellow mustard 25, alfalfa and red clover 50, and reed canarygrass 85.

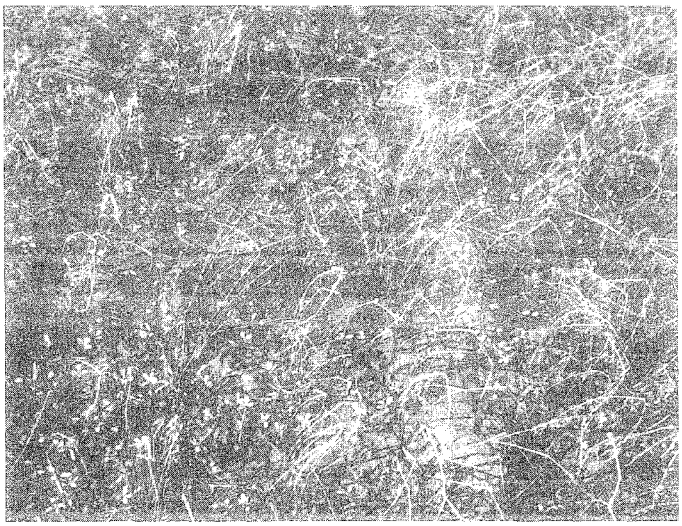

Figure 3. Camelina on April 24. Seed was broadcast in flax stubble December 2.

Response to Fertilizer and Date of Planting

Recommendations for fertilizing flax, rape, and mustard are available, and these crops have many similarities with camelina. Consequently, these crops were included in a trial comparing nitrogen (N), phosphorus (P), and potassium (K) fertilizer on growth and yield of camelina planted April 14 and April 24 on a fertile silt loam soil (Table 5). The P and K were broadcast just before seedbed tillage April 14. The crops were grown in rows 12 inches apart to facilitate sidedressing of N on May 5.

N significantly increased yield, height, and lodging and delayed maturity of camelina at both dates of planting. Frost (28° F) on May 12 injured mustard, rape, and flax but did not affect camelina. Frost injury is not uniformly distributed, so it may affect apparent response to fertilizer of frost-susceptible crops. Flax, rape, and the April 24 planting of mustard showed only slight responses to fertilizer, but fertilizer greatly increased yield of the early mustard planting.

A significant increase in yield from P and K was not expected because soil tests prior to fertilizing showed high P and medium K. However P and K injured the April 24 planting of camelina and to a lesser extent that of mustard, but had no harmful effects on the early plantings. Depth of planting may be a factor in the differing tolerances to P and K because camelina was planted very shallow, rape and mustard intermediate, and flax relatively deep. Toxic concentrations of P and K may have been present during germination and emergence of the April 24 planting and absent when the April 14 planting developed. Potential injury can probably be avoided by fertilizer placement and/or time of application.

Camelina planted April 14 outyielded the later planting in both fertilizer and no fertilizer treatments.

Performance as a Fall-sown Crop

More winter annual or fall-sown field crops would benefit Minnesota agriculture. Research on fall-sowing has been a research objective for over 30 years. One trial compared fall and spring plantings of camelina, yellow mustard, rape, and turnip rape. Broadcast plantings of seed on December 1, April 11, and April 26 were compared with grain drill plantings in rows 6 inches apart April 26 (Table 6). Seedbeds were tilled for the April 26 plantings but not for the earlier plantings, which were planted before the soil was dry enough for tillage. The best stands and weed control for all crops were obtained with conventional seedbed preparation and drilling, but camelina and Target rape had satisfactory stands and weed control from fall planting.

Table 5. Comparative response of camelina and yellow mustard at two dates of planting, oilseed rape, and flax to NPK fertilizer at Rosemount, 1969

Fertilizer/acre (pounds)			Seed yield/acre (pounds)	Date mature	Height (inches)	Lodging (percent)
N	P_2O_5	K_2O				
			Camelina planted April 14			
0	0	0	1390	7-20	26	21
80	0	0	1870	7-24	29	50
0	40	0	1420	7-23	27	40
0	0	80	1570	7-21	28	40
80	40	0	1870	7-24	29	60
80	0	80	1650	7-24	27	60
			Camelina planted April 24			
0	0	0	1350	7-25	31	31
40	0	0	1740	7-27	32	60
0	40[1]	0	1160	7-28	31	30
0	0	80[1]	1210	7-31	32	31
40	40[1]	0	1390	7-30	30	40
40	0	80[1]	1400	8-2	33	41
			Ochre yellow mustard planted April 14			
0	0	0	850	7-28	33	40
80	40	0	1810	7-27	30	50
80	0	80	1680	7-26	33	50
			Ochre yellow mustard planted April 24			
0	0	0	1140	8-3	32	40
40	40[1]	0	1260	8-5	39	40
40	0	80[1]	1260	8-6	34	50
			Target rape planted April 14			
0	0	0	1210	8-12	38	20
80	40	0	1310	8-4	36	30
80	0	80	1220	8-5	38	40
			Windom flax planted April 24			
0	0	0	970	8-11	28	10
40	40	0	1090	8-12	29	10
40	0	80	1210	8-10	26	10
LSD 5%			290			

[1]The P and K fertilizer gave moderately severe injury to camelina planted April 24 and moderate injury to yellow mustard planted April 24; injury from P was greater than that from K.

Table 6. Comparison of fall and spring planting for camelina, Ochre yellow mustard, Target oilseed rape, and Echo turnip rape at Rosemount

Planting date	Seedbed tillage in 1967	Planting method	Seed yield/acre (pounds) Camelina	Ochre	Target	Echo
December 1, 1966	none	broadcast	500[1]	560	900	700
April 11, 1967	none	broadcast	870[1]	850	1150	590
April 26, 1967	disk-drag	broadcast	960	800	1000	990
April 26, 1967	disk-drag	drill rows	1050	670	1080	790
LSD 5%			220	220	370	320

[1]Hail on July 22 resulted in 67 percent seed loss from shattering of the mature, dry capsules in the December planting of camelina and a 43 percent seed loss in the April 11 planting. The other plantings and crops escaped damage except for a 7 percent loss in the April 26 planting of camelina and a 13 percent loss in the December planting of Echo turnip rape.

Compared to April 26 planting, maturity was advanced by 3 days for April 11 planting and by 7 days for fall planting. Plants from fall planting were from 2 to 12 inches shorter than those from April 26 planting and were 0 to 8 inches shorter than those from April 11 planting. Test weights per bushel exceeded 50 pounds for all crops and dates of planting. Oil percents did not differ significantly among dates of planting, and they ranged from 37 to 39 for camelina, 29 to 32 for mustard, 46 to 48 for rape, and 38 to 39 for turnip rape.

December planting did not result in significantly lower seed yields than conventional planting except for yellow mustard. The lower yields from December and early April plantings of camelina are attributed to hail that shattered the mature, dry seed capsules of the early plantings while the green capsules of the later plantings escaped injury. Had it not been for hail, all of the camelina plantings would have yielded more than 1,000 pounds per acre.

Camelina had the lowest cost of production because no insecticide was applied, whereas mustard, rape, and turnip rape required spraying for fleabeetle and lygus bug.

Further research indicated that fall-sowing of spring varieties of yellow mustard, rape, and turnip rape was not reliable because frost in March or April killed the young seedlings. However, winter varieties of these crops are available. Dwarf Essex is the common forage rape used in the upper Midwest as hog pasture (Figure 4). It is a true winter annual and will not produce seed the year of planting. However, it is not winterhardy in Minnesota.[5] Seed is imported from Europe or the Pacific Northwest.

The possibility that late fall planting of Dwarf Essex might permit vernalization of the seedlings and seed production in Minnesota led to its comparison with camelina. Broadcast plantings of seed on December 11, April 9, and April 21 were compared with grain drill plantings in rows 6 inches apart April 21 (Table 7). Planting rates per acre for Camelina were 12 pounds on December 11, 8 pounds for the April broadcast plantings, and 4 pounds for the grain drill planting. The April 21 plantings had conventional seedbed preparation in 1969.

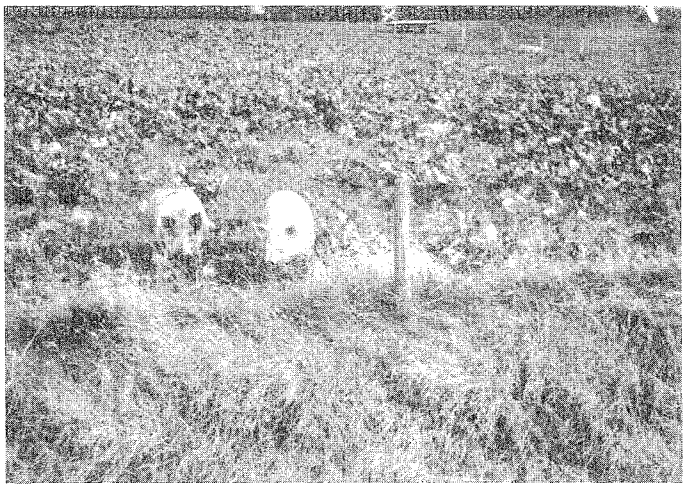

Figure 4. Hogs on rape pasture in October. The rape was sown in mixture with oat in early spring. Hogs pastured oat until July and then rape until November.

Table 7. Comparison of planting dates for camelina and Dwarf Essex winter forage rape

Planting date	Planting method	Stand, May 1 Rape (percent)	Stand, May 1 Camelina (percent)	Camelina Mature (July)	Camelina Weed control (percent)	Camelina Test weight/ bushel (pounds)	Camelina Protein (percent)[1]	Camelina Oil (percent)[1]	Camelina Yield/acre (pounds)
December 11, 1968	broadcast	10[2]	99	12	100	53	24	39	1220
April 9, 1969	broadcast	5[2]	80	18	90	53	24	37	1250
April 21, 1969	broadcast	5[2]	83	23	90	54	23	35	970
April 21, 1969	drill rows	–[2]	100	20	90	53	—	37	1050
LSD 5%									190

[1]Oven-dry basis. [2]Stands became 100 percent later because of late germination and seed washing from April-planted to December-planted plots. None of the rape plants flowered, indicating that no vernalization occurred.

[5]Robinson, R.G. 1956. We're looking for hardy winter annual field crops. Minnesota Farm and Home Science 14(1):16.

December and early April broadcast plantings of camelina matured earlier and yielded more than conventionally planted camelina. Rape was slow in emergence compared with camelina so emergence was incomplete by May 1. However plants emerging in May would have insufficient exposure to low temperatures for vernalization. The plots were left until fall and not a single rape plant flowered, so December planting did not result in vernalization and seed production of rape.

Comparison of Camelina with Flax Using Standard Farm Machinery on Large Plots

Flax, a conventional crop, and camelina, a potential crop, are similar in maturity and machinery requirements and probably have similar niches in a crop rotation. Broadcast camelina sown in late fall or spring with or without seedbed preparation and with no herbicide yielded as much as flax sown in the conventional manner and sprayed with herbicides (Table 8). The camelina matured about 3 weeks earlier than Windom flax (Table 9). These trials and those which follow were all handled entirely with standard farm machinery except for broadcasting of camelina (Figure 5, 6). A Cyclone hand-cranked seeder was used to broadcast seed 10 feet to each side (20-foot spread) as the operator walked across the field.

Planting Camelina in Cover Crops

Broadcast sowing by aircraft and camelina's low rate of seeding contribute to a very low cost of production per acre. But large fields of camelina might be subject to severe wind or water erosion if there were insufficient weed or crop residue cover. Consequently, camelina was planted in late fall in cover crops that were planted August 24 to September 8 (Table 10).

Performance of camelina was better with than without cover crops. Camelina with cover crops had better stands, tended to have fewer weeds, had less lodging, and had equal to slightly higher yields than camelina on soil without vegetative cover. Flax gave uniform cover and stayed erect all winter. Oat gave the most cover but tended to mat down on the soil, but this did not prevent camelina establishment. The yield of camelina from the camelina cover-crop plots was lower than that on the flax cover-crop plots, but further testing of camelina cover-crop is needed. Sunflower was tested only 1 year, because of potential disease problems from noncrop sunflower in rotations that might include sunflower as a crop.

Table 8. Comparative yields of broadcast-sown camelina in the fall or spring and drill-sown flax at Rosemount, 1970-73

	Planting		Seedbed	Seed yield/acre				
Crop	date	rate/acre (pounds)	tillage in spring	1970	1971	1972 (pounds)	1973	1970-73
Camelina	11/28-12/2	11	no	770	750	1110	1560	1050
Camelina	4/12-4/26	7	yes	680	750	1150	1540	1030
Flax[1]	4/12-4/26	50	yes	860	300	850	1650	910
LSD 5%				180	140	130	130	70

[1]Sprayed with dalapon and MCPA for weed control.

Table 9. Broadcast-sown camelina in the fall or spring compared with drill-sown flax at Rosemount, 1970-1973

	Planting		Seedbed			Weed			Seed[1]	
Crop	date	rate/acre (pounds)	tillage in spring	Stand (percent)	Date mature	control (percent)	Height (inches)	Lodging (percent)	protein (percent)	oil (percent)
Camelina	11/28-12/2	11	no	82	7-9	77	27	30	26	34
Camelina	4/12-4/26	7	yes	97	7-18	69	26	26	26	34
Flax[2]	4/12-4/26	50	yes	100	8-2	76	24	19	26	36

[1]Oven-dry basis. [2]Sprayed with dalapon and MCPA for weed control.

Table 10. Comparison of camelina broadcast-sown on bare soil and in cover crops drill-sown between August 24 and September 8, 1971-73

	Camelina										
			Weed			Seed[1]		Seed yield/acre			
Cover crop and rate/acre (pounds)	Stand (percent)	Mature (July)	control (percent)	Height (inches)	Lodging (percent)	protein (percent)	oil	1971	1972	1973 (pounds)	1971-73
None	77	11	78	28	37	27	34	750	1110	1560	1140
Flax, 14	89	9	83	27	18	28	34	1000	1050	1670	1240
Oat, 32[2]	89	10	92	28	18	—	35	840	—	—	—
Camelina, 4[2]	74	8	73	27	18	—	—	790	—	—	—
Sunflower, 13[2]	89	9	83	29	28	—	—	—	1080	—	—
LSD 5%								140	130	130	80

[1]Oven-dry basis. [2]Nonyield data for single years adjusted to be comparable with 1971-73 data.

Planting Methods for Camelina

Broadcast sowing of camelina on frozen soil in the fall and spring and broadcast and drill sowing on tilled seedbeds were compared at Rosemount for 3 years (Table 11). Plantings on frozen, untilled soil compared with later plantings on tilled soil gave equal stands, much better weed control, slightly taller plants, more lodging, equal test weight (50 pounds), equal protein (26 percent), equal oil (33 percent), slightly higher yields, and much earlier maturity. Drill planting on tilled soil produced the lowest yields. However, the differences among these four planting methods are probably more influenced by date of planting differences than by differences in tillage or seed distribution techniques.

Table 11. Camelina broadcast-sown on frozen soil in the fall and spring, and broadcast and drill-sown on tilled soil in the spring at Rosemount, 1970-72

Planting			Seedbed			Weed			Seed yield/acre			
Method	Date	Rate/acre (pounds)	tillage in spring	Stand (percent)	Mature (July)	control (percent)	Height (inches)	Lodging (percent)	1970	1971	1972	1970-72
									(pounds)			
Broadcast	11/28-12/2	11	no	92	9	72	27	37	770	750	1110	870
Broadcast	3/24-4/14	7	no	90	14	76	28	36	920	760	1130	940
Broadcast	4/12-4/26	7	yes	96	18	58	26	31	680	750	1150	860
Drill[1]	4/12-5/16	4	yes	92	21	32	25	26	460	680	750	630
LSD 5%									180	130	130	90

[1]Rows 6 inches apart.

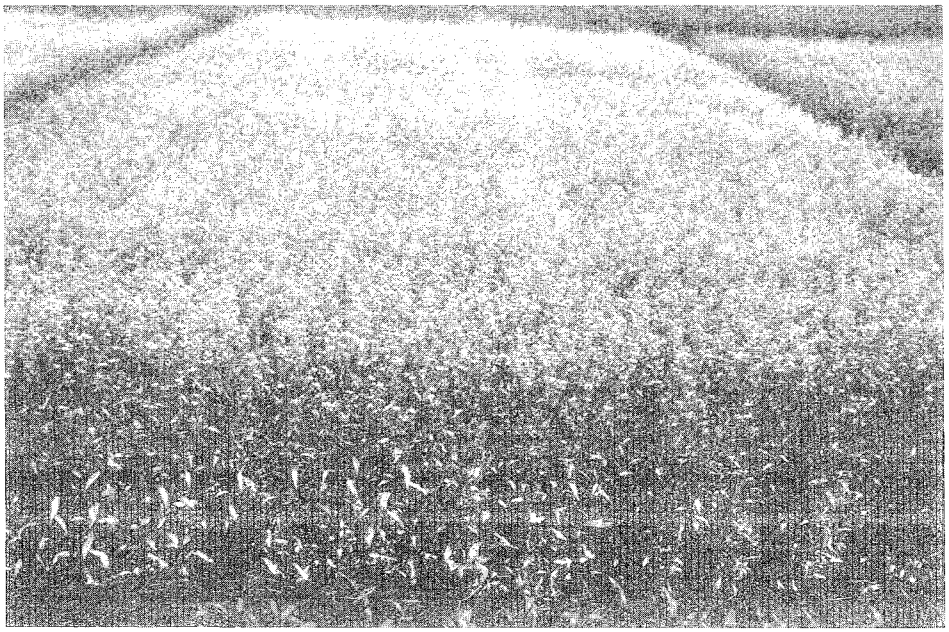

Figure 5. Camelina on June 8 already has capsules, seeds, and flowers. Seed was broadcast-sown in December.

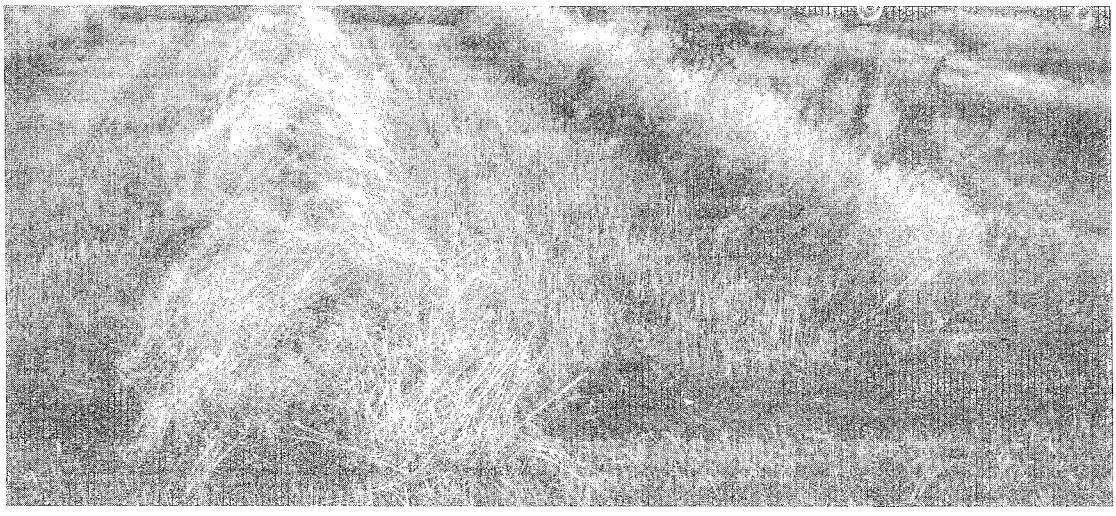

Figure 6. Camelina cut with a swather (windrower) on July 12 and drying in the windrow.

Camelina Tolerance to Trifluralin Herbicide

Use of trifluralin (Treflan) herbicide greatly increases cost of producing camelina because it requires both seedbed tillage and herbicide. However, information on tolerance to trifluralin is needed if camelina is to be used in mixed cropping and crop rotations. Trifluralin tilled into the soil in the fall or spring followed by broadcast-sowing of camelina in the fall or spring increased weed control and did not injure camelina, but it increased cost of production per acre and per pound of yield (Table 12). Furthermore, no herbicides are approved for weed control in camelina.

Fatty Acid Composition of Camelina Oil

Camelina is a potential oilseed crop, and vegetable oil characteristics and uses are determined by fatty acid composition. A complete fatty acid profile of oil from seed produced at Rose-

Table 12. Broadcast-sown camelina following no herbicide and disk-incorporated trifluralin in the fall and spring at Rosemount, 1970-72

Trifluralin[1]		Camelina	Seedbed	Stand			Weed control			Seed yield/acre		
Rate/acre (pounds)	Date sprayed	planting date	tillage in spring	1970	1971	1972	1970	1971	1972	1970	1971	1972
				(percent)			(percent)			(pounds)		
0	—	11/28-12/2	no	98	77	100	73	60	83	770	750	1110
1	10/28-11/5	11/28-12/2	no	97	75	—	97	77	—	830	780	—
1	10/28-11/5	4/5-4/14	no	83	72	—	93	77	—	910	730	—
1	10/28	4/12	yes	—	100	—	—	93	—	—	750	—
1	4/12-4/26	4/12-4/26	yes	—	100	100	—	91	90	—	790	1250
LSD 5%										180	140	130

[1]Sprayed and then mixed with the soil by two passes of disk-drag.

N Fertilizer on Broadcast-sown Camelina

Side-dressed N fertilizer increased yield of drill-sown camelina planted in the spring on a tilled seedbed (Table 5). Top-dressed N fertilizer on camelina broadcast-sown in fall or spring increased yield in 1 of 3 years, and for fall planting it delayed maturity by 7 days, increased height by 4 inches, and increased lodging by 18 percentage points (Table 13). N decreased oil by 1 or 2 percentage points in all trials. Yield, maturity, and height were not significantly affected by N treatment in 2 of 3 years. Lodging was increased by N in 2 of 3 years. These trials were on bare soil; a greater response to N could be expected on seedbeds with vegetative cover.

Table 13. Effect of N fertilizer in the spring on camelina broadcast-sown in fall or spring at Rosemount, 1970-72

N/acre (pounds)	Planting date	Seedbed tillage in spring	Seed yield/acre 1970	1971	1972
			(pounds)		
0	11/28-12/2	no	770	750	1110
66	11/28-12/2	no	1070	660	1110
66	4/5-4/14	no	1070	730	—
66	4/12	yes	—	670	—
LSD 5%			180	130	130

Elemental Composition of Camelina Seed

Elemental composition data for camelina seed is useful for comparison with other crops and for estimating fertilizer needs and nutrient removal from the soil. Camelina and flax were compared in elemental concentrations and soil depletion for 4 years (Table 14). Concentrations (columns 2 and 3) show that camelina and flaxseed are very similar except for the much higher concentration of sulfur in camelina.[6] However, nutrient removal per acre (columns 4 and 5) was greater for camelina than for flax because camelina seed yields averaged 960 pounds per acre compared with only 670 pounds per acre for flax.

Table 14. Average elemental concentrations in camelina and flax seeds harvested from date of planting trials at Rosemount and average elemental contents per acre of the seeds, 1969-72[1]

Element	Concentrations		Contents	
	Camelina	Flax	Camelina	Flax
	..... (percent).....		...(pounds/acre)...	
Nitrogen	4.08	4.09	39	27
Potassium	0.84	0.88	8	6
Phosphorus	0.78	0.80	7	5
Sulfur	0.66	0.27	6	2
Magnesium	0.32	0.36	3	2
Calcium	0.26	0.21	2	1
Sodium	0.01	0.08	<1	1
	(parts/million)		(pounds/acre)	
Iron	100	108	<1	<1
Zinc	57	71	<1	<1
Manganese	21	22	<1	<1
Aluminum	18	11	<1	<1
Boron	12	13	<1	<1
Copper	8	17	<1	<1
Strontium	8	6	<1	<1
Molybdenum	6	6	<1	<1

[1]Oven-dry moisture basis. Yields of camelina and flax averaged 960 and 670 pounds per acre, respectively.

[6]High sulfur concentrations are common in seed of other cruciferous crops. Yellow mustard in a nearby trial produced seed of 1.52 percent sulfur.

mount indicates that camelina oil differs from that of any other common oilseed crop (Table 15). The oil differs from that of linseed (flax) oil in its lower linolenic and higher eicosenoic concentrations and the presence of eicosadienoic and erucic acids not found in flax. Camelina oil differs from rapeseed oil in its low erucic and high linolenic concentrations. It differs from canola oil in its much lower oleic and higher eicosenoic and linolenic concentrations.

Camelina oil from seed produced at Rosemount had 11.3 percent saturated and 88.4 percent unsaturated fatty acids, of which 50.2 percent were polyunsaturated. The iodine value was 144, so it is classified as a drying oil.

Table 15. Fatty acid concentrations in oil from camelina seeds produced at Rosemount

	Fatty Acid		
Name	Carbon atoms	Double linkages	Concentration
	.....(number).....		(percent)
Linolenic	18	3	27.9
Linoleic	18	2	18.7
Oleic	18	1	17.5
Eicosenoic	20	1	16.4
Palmitic	16	0	6.0
Erucic	22	1	3.5
Stearic	18	0	2.8
Eicosadienoic	20	2	2.0
Arachidic	20	0	1.8
Eicosatrienoic	20	3	1.0
Tetracosenoic	22	1	0.6
Docosatrienoic	22	3	0.4
Behenic	22	0	0.4
Docosadienoic	22	2	0.2
Tetracosanoic	22	0	0.2
Palmitoleic	16	1	0.2
Myristic	14	0	0.1

Based on the desired attributes of edible, industrial, and drying oils, camelina oil has both advantages and disadvantages for all three major uses of vegetable oils. The lack of a precise adaptation to one use may be a serious limitation to its value.

Uses and Potential Uses

A major potential use of camelina is as an oilseed crop with a lower cost of production than any other oilseed crop. Vast acreages could be sown by aircraft in late fall using only 10 pounds of seed per acre. No other field operations are required except harvest by windrower and combine. However, camelina cannot compete successfully with perennial weeds. Uses for the oil need to be developed. Research at Rosemount showed that camelina oil can be used as a replacement for petroleum oil in pesticide sprays.[7]

Camelina is a useful plant for inexpensive soil cover and ornamental plantings. The dried plants with capsules may contribute to interesting floral arrangements.

Camelina is uniquely effective in research areas to provide soil cover and competition and to prevent seed mixture between adjacent plots (Figures 7, 8, 9, 10). Its tolerance to trifluralin allows it to be used as a border in many leguminous and cruciferous crops where trifluralin is a major herbicide. If some camelina seed is harvested with the desired crop, separation by sieving is easy, and camelina can be blown out of high density seed by wind.

Removal of camelina seed from other crops or obtaining pure camelina seed is accomplished on a common fanning mill. Wind settings and screens may vary with seedlot, but initial specifications for obtaining pure camelina seed are the lowest wind setting; a standard 1/22 round-hole sieve on top to let the camelina through; and a wire, square-mesh sieve with 28 squares per linear inch for the bottom sieve to hold the camelina.

Insects and Diseases

Damage to camelina from insects and diseases has not been sufficient to warrant control measures in 30 years of production on research plots. However, favorable past experience does not guarantee that losses will not occur in the future.

Plants with aster yellows virus disease are often found in camelina plantings. Another common disease is downy mildew (*Peronospora camelinae*). It is easily identified by the white or gray mold on the upper part of the stem, and diseased stems are often twisted or curved (Figure 11). Downy mildew also occurs on shepherdspurse weed, which may be an original source of inoculum. Camelina downy mildew is not related to sunflower downy mildew (*Plasmopara halstedii*), so it is not a consideration in crop rotations with sunflower. Camelina plants infected with aster yellows or downy mildew produce little or no seed.

Summary

Camelina was evaluated as a potential oilseed crop. The oil was used as a replacement for petroleum oil in pesticide sprays; other uses are possible. Camelina is also useful as a border plant in seed increase and research plantings of other crops. As a crop, camelina would have a very low cost of production per acre, but there is no market for the plant or seed. Camelina seed can be planted in rows or broadcast. Planting dates in very late fall, very early spring, and at normal spring planting dates for other crops were satisfactory. Camelina is similar to flax, rape, mustard, and canola oilseed crops in maturity, yield, and required harvesting machinery.

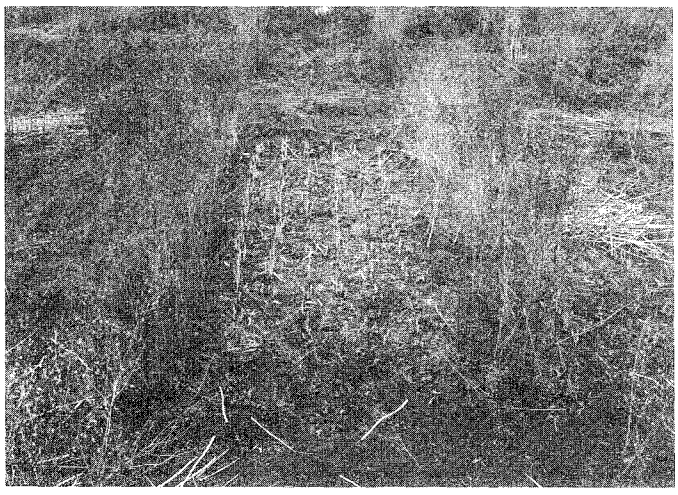

Figure 7. Camelina border rows still standing after canola plot (6 rows) has been harvested.

[7]Robinson, R.G. and W.W. Nelson. 1975. Vegetable oil replacements for petroleum oil adjuvants in herbicide sprays. Economic Botany 29:146-151.

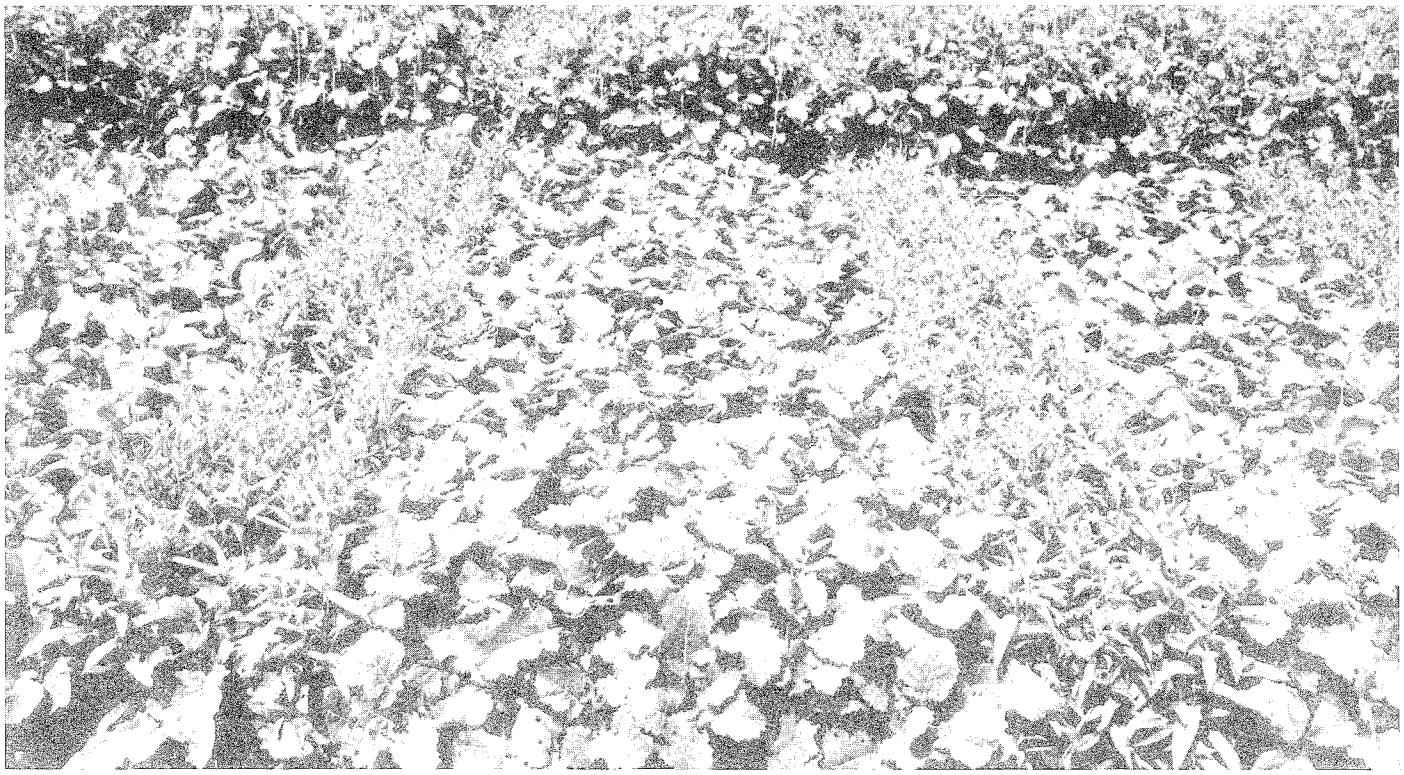

Figure 8. Camelina border rows separating varieties of forage rape.

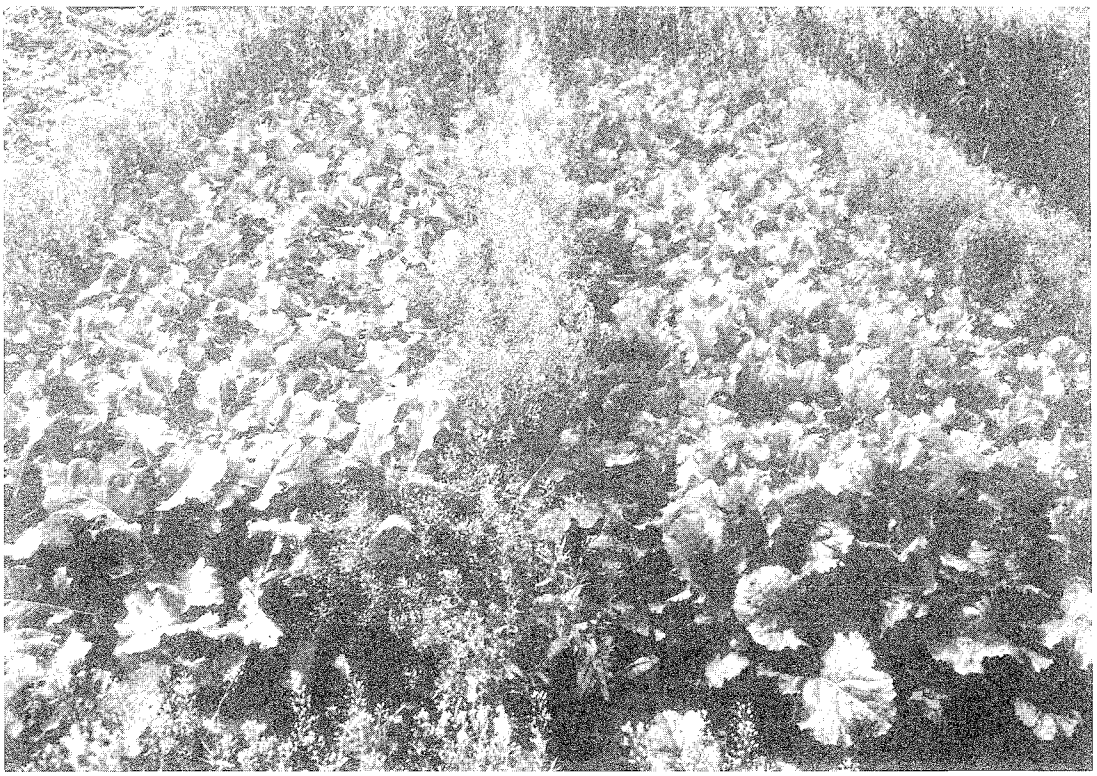

Figure 9. Camelina border rows separating forage rape left and tyfon right.

Figure 10. Camelina border rows separating fababean and fieldpea plots on irrigated sandy soil at Becker.

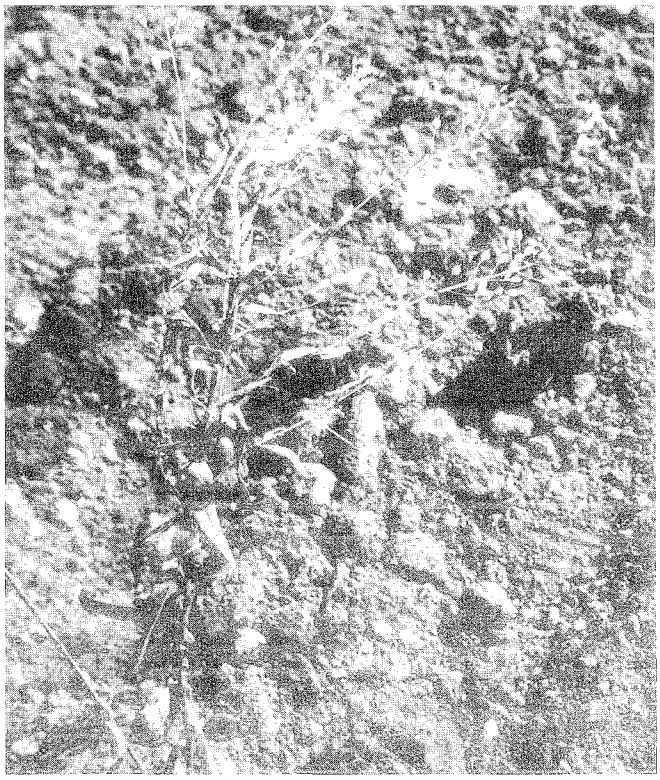

Figure 11. Bent stem symptom of *Peronospora* on camelina.

Robert G. Robinson is Professor Emeritus, Department of Agronomy and Plant Genetics, University of Minnesota