2004

EC04-183A Brown Mustard Production

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Brown mustard, *Brassica juncea*, originated from the hybridization of *Brassica nigra* with *Brassica campestris*. This probably happened in southwestern Asia and India where the natural distribution of the two species overlaps. Brown mustard has been grown for oilseed, greens, and as a spice. In the 1940s, a yellow-seeded variety of brown mustard was imported into the United States from China and became widely cultivated because, unlike some other mustards, it could be mechanically harvested. Currently, efforts are underway in Canada to develop canola quality brown mustards for oil use; however, in the United States the market is primarily as a source of biodiesel.

The brown mustard plant has become recognized for improved heat tolerance relative to spring canola cultivars. It is a very flexible crop, responding well to a wide range of rainfall or to supplemental irrigation. Plants can branch and put on more flowers as moisture becomes less limiting; however, they will produce some yield even with very limited water.

Dryland cropping systems have moved from winter wheat-fallow to more intensive systems that include warm-season crops such as proso millet, sunflower, and corn. The availability of a spring-planted, cool-season broadleaf crop with an extensive market opportunity would have significant rotational benefits to High Plains producers. Brown mustard could emerge as such a crop.

Brown mustard may be used instead of summer fallow to transition from a full-season summer crop to winter wheat. Harvest normally occurs in early August, which allows four to six weeks to replenish surface soil water before planting winter wheat. Because brown mustard does not leave much residue after harvest, it is best not to follow brown mustard with summer fallow. Brown mustard is a good choice between cool- or warm-season grass crops in a crop rotation. It is important that winter annual weeds are prevented from producing seed in other phases of the crop rotation because it is difficult to control these weeds in brown mustard (see *Weed Management Section*). If plant disease is a concern, brown mustard should not be grown more than once in four years (see *Disease Management Section*).

Some possible dryland crop rotations involving brown mustard include:

1) Winter wheat-corn or proso millet-brown mustard
2) Winter wheat-brown mustard-proso millet-fallow
3) Winter wheat-corn-brown mustard-proso millet

A winter wheat-proso millet-brown mustard rotation may work well on shallow or coarse-textured soils with limited soil water holding capacity, where continuous cropping may make more sense than on deep silt or silt loam soils. Both non-wheat crops have a reasonable chance of producing an acceptable yield with average to above-average rainfall during the growing season, especially on coarser soils where water infiltration rates are good.

Irrigated rotations also will work well when the following crop is expected to be wheat. Most summer crops should be acceptable preceding the brown mustard crop, however, herbicide carryover issues should be monitored carefully (see *Weed Management Section*).

Brown mustard production uses small grain equipment, limiting the need for large investments in machinery. Planting costs of brown mustard are similar to those for wheat. The low investment costs and increasing consumer demand for biodiesel potentially make it a good alternative crop for Nebraska growers.

Figure 1. Brown mustard seedlings with cotyledons (top and bottom) and the first true leaves (left and right).

General Agronomics

Brown mustard seed is small (96,000 seed/lb), and management practices and field choices influence its yield performance. A field with good internal drainage is essential for stand establishment and yield because brown mustard does not tolerate standing water.

Brown mustard should be grown in fields not recently planted with canola or other cole crops (rapeseed, cabbage, broccoli, and turnips), or infested with weedy mustards. **Do not plant near a canola field. Pollen contamination may cause an intermediate type and could make both crops marketable only for industrial oil.** Brown mustard fits well into a one-in-four-year rotation schedule, which may decrease potential problems with sclerotinia, root and stem rot.

Figure 2. Brassica juncea grown at the University of Nebraska Panhandle Research and Extension Center in July 2003.

Seedbed Preparation

Proper seedbed preparation is essential for the successful establishment of brown mustard. Brown mustard needs a seedbed that is firm and well-packed to allow for proper seeding depth and seed-to-soil contact. After disking, a final harrowing or packing should create a firm, packed planting surface. Excessive tillage can cause soil moisture loss and surface crusting. The final tillage operation should occur less than a week before planting to kill weed seedlings, incorporate the herbicide, and move soil moisture into the seeding depth zone. A well prepared seedbed is essential for promoting emergence, achieving desired stands, and decreasing weed pressure. No-till systems optimize planting without depleting stored winter moisture; however, weed control programs for no-till systems have not yet been developed for brown mustard (see *Weed Management Section*).

Planting Methods and Rates

Begin planting brown mustard in March when soil temperatures at planting depth are 40°F or warmer. Planting too early can reduce stand establishment due to cold soil temperatures. Brown mustard yields can decline with delayed seeding if crop flowering and seed fill occur under hot summer temperatures. In this region, it is generally best to plant early rather than late as that leaves more recrop options if stands fail.

Seeding rates range from three to six pounds pure live seed per acre. Use seeding rates of eight to ten pounds if the crop is to be planted in irrigated, weedy, or high surface residue fields or when using broadcast spreaders for planting. The higher seeding rates produce stems that are more sensitive to lodging, but the added plant density will reduce time to maturity. A shorter maturation period might be better in late spring plantings. Use seeding rates of three to five pounds for areas where late season drought can be a problem.

The size of brown mustard seed limits planting depths to 1/8 to 1 1/2 inches. Seeding depths of 1/2 to 1 inch are optimal when moisture is adequate.

A grain drill is desirable for seeding brown mustard. Drills with 6- to 12-inch row spacings are adequate. The narrow row spacings will enable the stand to cover the soil surface more quickly and reduce weed competition. Growers should consult their drill's calibration charts for the proper settings. Disk openers are better than hoe-type openers because of their improved precision in seed placement and the fact that the seedlings endure a three- to four-week period of susceptibility to soil covering. Hoe-type openers may be more desirable in rough fields. Broadcast spreaders with harrow incorporation of seed can produce uneven stands due to poor seed placement. While final plant populations of 10-12 plants per square foot (dryland) and 14-16 plants (irrigated) are ideal, weed-free stands of two to four plants per square foot are salvageable because brown mustard compensates by branching in thin stands.

Soil Fertility

Soil testing is the most effective monitoring device a grower can have to manage soil fertility. Brown mustard will benefit from proper fertilization. Adequate levels of nitrogen, sulfur, phosphorus, and potassium are essential for rapid stand establishment and optimum yields.

Brown mustard is a heavy nitrogen and sulfur user, showing greater response to high nitrogen (wheat recommendation x 1.25) and especially sulfur (wheat recommendation x 2) than wheat and barley. It needs a total availability of 150 pounds of nitrogen to produce 3,500 pounds of grain per acre. An early spring application is as effective as split

applications. Brown mustard is sensitive to fertilizer salt burning with furrow applications of both nitrogen and sulfur. Where soil moisture might be limiting during germination, in-furrow nitrogen and sulfur applications are discouraged.

Brown mustard's phosphorus and potassium requirements are similar to those of high yielding wheat crops. Regional soils typically have high residual potassium levels and a response from potassium fertilizer would not be expected. Apply both nutrients as a preplant treatment according to soil test results. Optimum soil pH is 5.8 to 7.8. Boron is a pH sensitive micro-nutrient which may become deficient in sandy and high pH soils. Brown mustard uses more boron and sulfur than other crops in the rotation. Growers should be careful to avoid elevating boron soil concentrations to toxic levels. Boron is applied preplant.

Brown mustard needs sulfur to take advantage of the higher nitrogen amounts. Generally, it should be applied to achieve a soil test plus applied ratio of 1 lb sulfur to 6 lbs nitrogen. Apply sulfur preplant in forms that are more readily available, such as ammonium sulfate or ammonium thiosulfate rather than elemental sulfur.

Weed Management

Growers should be aware of brown mustard's sensitivity to several broadleaf herbicides. Avoid fields with residual levels of triazines, imadazolinones, some sulfonylureas, picloram, and dicamba (for example: Ally, Amber, AAtrex/Atrazine, Banvel, Beyond, Finesse, Peak, Pursuit, Raptor, Rave, and Tordon). Refer to herbicide labels and herbicide consultants for potential problems with residual herbicides.

Weeds and volunteer crops in brown mustard fields should be destroyed before planting. Preplant tillage can control weeds and volunteer wheat, but a tillage-herbicide program will control problem infestations better than tillage alone. Treflan/Trifluralin is registered for use on brown mustard, but it will not control wild oats (*Avena fatua* L.) and many weedy mustards. Growers should be sure to prevent these weeds from going to seed in previous crops in the rotation. If Treflan is to be applied, note that it requires soil incorporation within 24 hours of application.

Postemergence control of grass weeds in brown mustard may be achieved with Select or Prism herbicides. These grassy weeds are more economically controlled with tillage and Treflan/Trifluralin herbicide, but the use of Select or Prism may be warranted if extreme grass weed infestations occur.

Until other weed control options are developed for use in no-till brown mustard production, no-till producers may want to consider substituting herbicide-resistant (Clearfield, Liberty-resistant, or glyphosate-resistant) spring canola for brown mustard. Be sure to use adapted varieties.

Disease Management

Several diseases can reduce the yield potential of brown mustard, but proper management practices can reduce the threat of disease. These practices include a one-in-four-year crop rotation and the use of disease-free, certified seed.

Sclerotinia sclerotiorum (white mold or stem rot) survives in soil in its dormant stage called sclerotia. The stem, branches, pod, and leaves can become infected. The chance of white mold infection is increased by excessive use of nitrogen fertilizers, high inoculum levels, high plant populations, and high humidity. Effective control measures include rotating to nonhost crops, deep plowing, and use of certified seed free of sclerotia. Other host crops for this disease include dry bean, sunflower and chickpea.

Black spot, *Alternaria brassicae* and *A. raphani*, is present in all brown mustard and rapeseed production areas. Black spot overwinters on plant debris and seed. All above-ground plant parts are susceptible to infection from the spores produced on plant debris or infected seed. To limit problems, use disease-free certified seed, a one-in-four year rotation, and control weedy mustards and volunteer brown mustard.

Seed rots, seedling blights, and root rots caused by species of *Fusarium, Pythium sp.* and *rhizoctonia* can reduce brown mustard stands. Proper seedbed preparation will create conditions favorable to rapid germination and seedling emergence. Seedling rots infect the emerging seedling and can prevent emergence or leave the plant susceptible to other pathogens. Root rot symptoms include lesions at the stem bases and on the roots that can weaken or kill the plant. The fungicide, Captan, has been effective in preventing seed rots, but it does not protect against seedling blights and root rots. Recommended control practices include Captan seed treatment for the seed rots and rotating to nonhost crops.

Stem canker or black leg caused by *Phoma lingum* is a devastating brown mustard disease in Canada. Infected disease stocks or aerial spores spread stem canker. The reuse of common infected seed lots also spreads stem canker. Certified seed treated with benomyl is good insurance in Nebraska where the total brown mustard acreage is low. If stem canker gets a foothold, plowing and a one-in-four-year rotation will help control the problem.

Insect Pest Management

Several insects are known to infest brown mustard; however, little is known of the potential for these insects to significantly damage brown mustard in production fields in western Nebraska. Flea beetles are the most likely insects to severely damage mustard, and they have been observed causing serious damage in western Nebraska. Early season cutworm damage also may threaten stands in some fields. Cabbage seedpod weevil is a major pest in Idaho, but its occurrence in Nebraska is unknown. Aphids have been observed in Nebraska, but are not likely to be present in great numbers early enough to cause severe damage. There is little information available about the economic thresholds of most of Nebraska's brown mustard pests, but regular monitoring of fields to guard against insect problems is essential.

Flea beetles first become active in the spring when temperatures exceed about 58°F, and are most likely to feed on warm sunny days. The beetles will feed on the leaves of the mustard and create small circular pits or shot hole damage. The cotyledon stage is most susceptible to damage because the plants cannot tolerate rapid defoliation and the

associated water loss from this type of feeding. Once the first true leaves have developed, damage potential is reduced because plants can more easily tolerate defoliation. The insect is of little concern after the two- to four-leaf stage unless there are extreme populations.

Flea beetle management should rely on multiple tactics. Plant early so plants are established before the beetles become active, and use seed treatments to increase the likelihood of plants surviving any early damage. Scout fields regularly to determine the presence of feeding adults on the young mustard plants. The treatment threshold for cotyledon mustard is when 25 percent of the plants are showing feeding injury and beetles are present. Foliar treatments should then be applied quickly to stop damage from accumulating. Re-infestation can occur, so treated fields should be monitored again after the insecticide activity has ceased (after five to seven days).

The army cutworm is the most likely cutworm to threaten mustard stands early in the season. These cutworms will be active in March and April and are most likely to be present where cereal cover crops are present or in fields that had significant weed growth in the fall and winter. Army cutworm adults lay eggs in the fall. The eggs hatch rather quickly and the larvae will feed in the fall and winter on numerous hosts. If these hosts are removed in the spring, the cutworms will move to the developing mustard. Pale western cutworm also may cause problems in the early spring. Their eggs are also laid in the fall but hatch early in the spring. The adult moths are attracted to newly tilled or loosened soil in September. Other cutworm species may damage mustard later in the spring, but the potential for severe damage from these is lower.

False chinch bugs have been identified as a problem with mustard production. This insect will most likely be damaging in mid-summer as it moves from other hosts to brown mustard. Early in the season it is attracted to weed species, including shepherd's-purse and other mustards.

Figure 3. Flea beetles injure brown mustard by poking pin holes in small leaves. As the leaves grow and expand, so does the size of the hole.

False chinch bugs will feed on foliage and later flowers and buds to cause damage. They may move suddenly into a field in large numbers and just as suddenly move out of the field.

In other growing regions, cabbage seed weevil has become a problem; however, in Nebraska, this insect has not been seen. Often brown mustard flowers late enough to avoid cabbage seed pod weevil. If the adults emerge and lay their eggs when brown mustard is in full bloom, larvae will develop on the immature seed in the pods. The larvae are the destructive stage of this insect; however, economic threshold limits have not been set for this insect.

Aphids can be found feeding on terminal flowering structures during flowering and pod-fill, but unless populations are extreme, they do not reduce yield because terminal pods contribute little to yield.

Grasshoppers, armyworms, diamondback moth larvae and cabbage worms are defoliators that feed on leaves and seed pods. Heavy infestations of these insects and subsequent defoliation can reduce yield. It is important to scout mustard fields regularly to determine the presence of significant populations of these insects.

Irrigation

Brown mustard has the potential to respond to various supplemental irrigation levels because of its indeterminate type of branching. Optimum yields will be achieved by irrigation levels similar to irrigated spring

Advantages of Brown Mustard

Potential benefits of growing brown mustard include:

Dryland Production

1) The use of current small grain equipment reduces investment costs.
2) Adding another crop to a rotation will help break pest cycles.
3) A spring-seeded crop spreads out the farm work load and provides an early summer cash crop that may produce more income than wheat.
4) The use of a minor oilseed crop allows a farmer to maximize government farm program alternatives with flex acres.
5) Diversification into a different market helps manage market risk.

Irrigated Production

1) A cool-season crop can spread peak water requirements relative to corn, beets and beans.
2) Rotation with irrigated winter wheat works well as long as winter annual weeds are controlled in the wheat.

Table I. Projected revenue and cost of production for brown mustard (*Brassica juncea*) under conventional dryland and irrigated systems.

Projected Revenue

Brown Mustard	*Yield lb/Acre*	*Price $/lb*	*Total Revenue*	*Total Revenue*
Dryland	850	0.12	$102.00	——
Irrigated	2500	0.12	——	$300.00

Variable Costs

	Cost per Acre				***Dryland***	
	Labor	***Fuel & Lube***	***Repairs***	***Materials & Custom***	***Conv. Till Total***	***Irrigated Total***
Spray - Fall	Custom		13.00	13.00	——	
	Roundup Ultra 20 oz/acre @ $0.31/oz					
	Banvel 4 oz/acre @ $0.70/oz					
	Custom Spray @ $4.00/acre					
Disc	1.00	0.76	0.90	0.00	2.66	2.66
Spread Fertilizer	0.78	0.28	0.10		11.56	40.16
	Fertilizer 40 lb N - Dryland		10.40			
	Fertilizer 150 lb N - Irrigated			39.00		
Incorporate Chemical	0.67	0.38	0.50	9.60	11.15	11.15
	Treflan 24 oz/acre @ $0.40/oz					
Plant	0.68	0.47	1.22	10.00/16.00	12.37	18.37
	Brown Mustard Seed 5 or 8 lb/acre @ $2.00/lb					
Spray for Flea Beetles 50% of acres	Custom			5.46	5.46	5.46
	Warrior 3.2 oz/acre @ $2.16/oz					
	Custom Spray @ $4.00/acre					
Pivot Irrigate	3.33	21.72	6.51	2.50	——	34.06
	Connect Charge $2.50/acre					
Combine	1.52	1.46	1.62	0.00	4.60	4.60
Haul						
Dryland				1.19	1.19	——
Irrigated				3.50	——	3.50
Operating Interest @ 8% for 8 months					3.31	6.40
General Overhead					3.26	6.32
Total Variable Costs					**$68.56**	**$132.67**

Fixed Costs

Machinery		
Depreciation	11.59	11.59
Interest	7.80	7.80
Coop Shares	5.00	50
Irrigation		
Depreciation	—	16.97
Interest	—	11.03
Total Fixed Costs	**$24.39**	**$52.39**
Total of All Costs	**$92.95**	**$185.06**
Return to Land and Management	**$9.05**	**$114.94**

wheat or oats. If adequate water is available for growth, brown mustard will use 17-19 inches of water during the growing season. Because planting occurs in March, brown mustard plants can take advantage of normally abundant spring precipitation. By using water from the soil profile early, it is less likely water will move below the root zone due to excessive spring precipitation. In addition, using spring precipitation effectively decreases the demand for irrigation water and shifts the need for irrigation to when water use is at its peak. During bolting (late May), brown mustard will be using one inch of water per week. During its peak growth in early June (bud-flowering), brown mustard will use nearly two inches of water per week and will continue at this level through flowering and initial pod fill. By early July (following pod set), water use will begin to decrease at a rate of approximately 0.3 to 0.4 inches per week until harvest in early August.

Irrigation timing becomes critical in June (during flowering). If adequate precipitation has occurred, irrigation can be delayed. Without adequate precipitation, soil water should be monitored at least twice a week. In some cases it may be difficult to keep up with water needs during the peak water use period because plant use can exceed the amount of water the irrigation system can apply. If this is the case, it is important to maintain a relatively full soil profile starting in early June so the plant can use both stored soil water and irrigation water to avoid plant water stress. Like most crops, water stress causes yield reduction, but because of brown mustard's flexibility in adding or dropping flowers, it is a more flexible crop than most.

Harvesting and Storage

Direct combine harvest of brown mustard is the most popular method in North America and Europe. Swathing is also possible when weed or humidity problems make direct harvest difficult. Harvest should not begin until seed moisture is below 10 percent. Delivering a crop above 10 percent moisture will result in dockage and the chance of heating damage during storage.

Growers usually use a combine with a reel head. Contact a dealer if the combine manuals lack the proper brown mustard settings. Brown mustard is a difficult crop to feed into the combine but it is an easy crop to thresh. The reels should be set high and reel speed should be set to match ground speed due to the chance of shattering. Periodic inspections are essential to insure that the harvesting equipment has no openings through which brown mustard can leak.

Swathing and threshing is practical when fields have heavy weed infestations. Seed moisture levels should be 30 percent or lower before swathing. When the seeds in the pods are 75 percent brown colored, the seed moisture should be about 30 percent. Threshing should start when the seed is at 10 percent moisture and no green seed is present. Swathing too early will result in green seed, lower oil content, and higher seed moisture. Swathing too late will result in excessive shattering.

Seed moisture should not exceed 8 percent for long-term storage. Lining the floor with a fine nylon or metal mesh screen will solve bin leakage problems. When drying seed, temperatures above 104°F can change the seed oil composition and kill germination. Seed stored below 6 percent moisture will be susceptible to damage in handling.

Economics and Marketing

There are few brown mustard markets in Nebraska. Currently, the primary market for brown mustard is with Blue Sun BioDiesel through Progressive Producers in Sidney, Nebraska. They require an equity position in the company for crop delivery. A minimum position of $5,000 will allow delivery from up to 200 acres per year. Contact the company directly for specifics. Further development of a commercial market will help make brown mustard an excellent alternative cash crop for Nebraska growers. *Table I* examines many of the costs involved with brown mustard production.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert Dickey, Dean and Director, University of Nebraska, Institute of Agriculture and Natural Resources.