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Planting Dates for Multiple Cropping of Biofuel Feedstock and Specialty Crops

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Use of alternative energy sources are a major focus for consumers and state and federal legislatures. Several crops can be used as biofuel feedstocks. However, it is not clear how these crops can be most efficiently produced in various areas of the country; which crops return the most biofuel products, and how to integrate the crops into production systems. The long-growing season and precipitation patterns in the southern plains should allow the production of many biofuel feedstock crops. A biofuel feedstock is anything that can be reduced to either ethanol or combustible oils. A question for producers of these crops is whether the production of biofuel feedstock crops should be the primary crop or integrated into existing crop rotations. Crop rotation is a sound cultural practice that should be considered by producers regardless of the type of annual crops being grown. To successfully integrate new crops as a primary crop, winter cover crop, or rotation crop, environmental requirements of each crop will either need to be established, or considered, to achieve desired biomass or seed production. Crops should be selected, based on environmental requirements for stand establishment, plant development, and biomass and/or seed harvest. Historic weather patterns for Oklahoma and surrounding states are available from the National Oceanic and Atmospheric Administration (http://www.noaa.gov) which can be accessed. With this knowledge, cropping sequences can be developed to expand crop diversity and planting flexibility. During certain parts of the year when weather patterns would prohibit growing specialty crops, conditions may allow production of selected biofuel crops.

Objectives of this study were to evaluate planting and harvesting windows for the biofuel feedstock crops: Indian mustard [*Brassica juncea* (L.) Czern.], Canola [*B. napus* (L.) Czern. var. *juncea*], var. Wichita, Sunflower (*Helianthus annuus* L.), Sorghum [*Sorghum bicolor* (L.) Moench], var. Della, and Sweet corn (*Zea mays* var. *rugosa* Bonaf.), cvs. Incredible (endosperm genotype *se*) and Honey'n Pearl (endosperm genotype sh_2). Sweet corn was grown for biomass for sugar conversion not for edible ears. Indian mustard can be used as either a soil biofumigant or a biodiesel feedstock. If used as a biofumigant the plant is turned directly into the soil at the beginning of flower formation. Materials in the vegetative tissue volatilize into the soil and act on soil microorganisms and seeds (Mayton et al., 1996; Olivier et al. 1999; Rosa and Rodrigues, 1999). Activity of materials in leaves is non-specific. It is recommended that sowing seed of a succeeding crop be delayed for about 1 month after the mustard is plowed under. Information is not available as to whether transplants can be established in the field during the 1 month after incorporating the Indian mustard biomass.

The time frame of these studies was from late-September 2006 to late-September 2007. All plantings, on unbedded soil, were at Lane on a Bernow fine-loamy, siliceous thermic Glossic Paleudalf soil. No more than 150 lbs/acre of 17-17-17 NPK fertilizer was applied at any planting. The period over which all planting and harvests occurred was one of the wettest on record (about 64 inches), with a large portion of the rain occurring during establishment, or harvest of several crops. The unusual precipitation events likely interfered with pollination, nutrient movement in the soil, or harvest, i.e., inability to enter the field, or extension of the time to dry the appropriate tissues on some crops.

What follows is a summary of preliminary experiments examining how planting date affected yield of some biofuel feedstock crops (Table 1). Only biomass was measured for Indian mustard. Canola and sunflower were harvested for seed yield. Sorghum and sweet corn was harvested for biomass. Sorghum and sweet corn were harvested when tassels were beginning to expand because it may be that more carbohydrates in a more easily extractable form, liquid expressed from cells, would be available before sugars were moved to the seed. Sweet corn stalk internode tissue senesces with age, the senescence increases as ears develop and mature (Russo and Pappelis, 1994). As senescence progresses it may be that extractable liquids would not be as available as they are more tightly held in the senescent cells in the stalks or moved to the seed and converted to starch. Additional chemical methods will be needed to make carbohydrates in senescent cells available for conversion to bioethanol.

For the single planting date of Indian mustard there was a biomass harvest of 6 T/ac. For canola, regardless of when it was planted in the fall of 2006, harvest was on the same date in 2007. For Sunflower the time to harvest was for the most part on the same day, for the first three planting dates, and only a week later for plants established at the last planting date. Yields of canola seed were higher for plants established at the later fall planting dates. When established in late-winter, canola produced a negligible seed harvest. Yield for sunflower seed appeared to be increased by planting in May and June rather than in April. There appears to be flexibility as to when these crops can be established and when they can be harvested.

Delaying the planting date for sorghum extended the harvest period in to late-August. Stalk yield of sorghum plants established at the second planting date was about 7 to 14% higher than the first and last planting dates. For the *se* sweet corn, time to harvest was reduced as planting date was delayed. For the sh_2 sweet corn the length of time to harvest was the same even though planting dates were a week apart. For both types of sweet corn, stalk yields appeared to increase as planting date was delayed. Appropriate harvest dates for sorghum and sweet corn seemed to be associated with planting date.

Expected yields in most cases were not achieved. This was likely due, in part, to insufficient fertilization and/or leaching of nutrients caused by the unusual precipitation levels. A more normal weather pattern, and a better understanding of the nutritional requirements of these crops, will likely improve yields. For all crops, additional information on planting dates, seed germination data, fertilizer requirements, and plant spacing are needed. For sweet corn additional, more robust, cultivars should be tested. Multiple cropping on the same land will be feasible, regardless of whether only biofuel feedstock crops are grown, or if there is a mix of biofuel feedstock crops and annual specialty crops. Multiple cropping can provide feedstocks for delivery to processing plants at various times during the year. In addition to the primary biofuel product, residues from the process can be turned under or converted into materials used in other industrial activities.

The crops tested represent a small sample of potential biofuel crops for production in the south central region of the US. Additional studies are proceeding to determine the temperature requirement for germination of these and other biofuel crops which will be critical for integration in various cropping schemes. Development of appropriate production systems is being undertaken with these and other biofuel, feedstock and specialty crops.

Literature

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Table 1. Planting and harvest dates, and yields of a biofumigant crop and various biofuel feedstock crops at Lane, OK.

Crop	Tissue	Use	Date: Planting	Date: Harvest	Bio-mass fresh weight (lbs/acre)
Indian mustard	Leaves	Biofumigant	23 Feb. 2007	24 Apr. 2007	12,000
Canola	Seed	Biodiesel	17 Sept. 2006	5 June 2007	420
			2 Oct. 2006	5 June 2007	170
			23 Oct. 2006	5 June 2007	900
			15 Nov. 2006	5 June 2007	700
			23 Feb. 2007	9 July 2007	10
Sunflower	Seed	Biodiesel	3 Apr. 2007	13 Aug. 2007	470
			30 Apr. 2007	13 Aug. 2007	230
			21 May 2007	13 Aug. 2007	600
			13 June 2007	21 Aug. 2007	550
Sorghum	Stalk	Bioethanol [Z]	13 June 2007	16 Aug. 2007	37,700
			9 July 2007	19 Sep. 2007	40,500
			18 July 2007	24 Sep. 2007	34,700
Sweet corn					
Genotype se	Stalk	Bioethanol [Z]	13 June 2007	2 Aug. 2007	4,170
(cv. Incredible)			9 July 2007	27 Aug. 2007	12,600
			18 July 2007	31 Aug. 2007	13,900
Genotype sh_2	Stalk	Bioethanol [Z]	9 July 2007	20 Aug. 2007	6,900
(cv. Honey'n Pearl)			18 July 2007	29 Aug. 2007	11,200

[Z] Liquids expressed from tissues and frozen; Brix (an indicator of levels of sugars present) will be obtained before the liquids are fermented at Lane to determine ethanol output.