ABSTRACT

Cool-season oilseed crops are potential feedstock for biofuel production, but few studies have compared oilseed-durum (Triticum durum Desf.) rotations on yield, quality, water use, and pests associated with crops. We conducted an experiment under dryland conditions during 2007 to 2010 near Culbertson, MT, comparing crop productivity, water balance, and key weed and arthropod pests of 2-yr oilseed-durum rotations under zero tillage. Rotations included durum with three Brassicaceae sp., camelina [Camelina sativa (L.) Crantz], crambe (Crambe abyssinica Hochst. ex R.E. Fries), and canola-quality Brassica juncea L., and fallow. Over 4 yr, B. juncea had the highest seed and oil yields of crucifer entries. Water use was similar among oilseed crops, averaging 286 mm. Water use was similar for durum following oilseeds, averaging 282 mm, 72 mm less than for durum following fallow. Durum following fallow averaged 775 kg ha−1 greater grain yield than durum following oilseeds due to higher water availability and use. Camelina had greater weed biomass at harvest and lower densities of Plutella xylostella L. than other oilseeds. Durum in rotation with crambe had higher weed density and biomass at harvest than durum following B. juncea or fallow. Brassica juncea generally performed better than crambe or camelina, but each oilseed crop had several positive attributes. Oilseed-durum rotations can be used for biofuel feedstock and grain production, but long-term sustainability of 2-yr rotations on crop yields and pest management requires further study.

The Energy Independence and Security Act of 2007 (summarized in Sissine, 2007) mandates the use of 136 billion liters of biofuel by 2022, with 79 billion liters projected to be advanced biofuels, including renewable diesel for naval ships and aviation jet fuel. The U.S. Department of Defense has established ambitious goals to purchase and use renewable fuels (Congressional Research Service, 2010; summarized in Tindal, 2011). However, current cropping systems in the United States may not be capable of producing adequate amounts of feedstock at prices competitive with petroleum-based fuels to meet desired production levels within the time stipulated in legislation and Executive Orders (Van Gerpen et al., 2008).

One region that is well suited and has a high potential for increasing agricultural production of biofuel crops is the semi-arid Northern Great Plains (NGP) in eastern Montana and western North Dakota. A common rotation in semi-arid dryland production systems in the NGP is durum–fallow. Replacing fallow with various cool-season oilseed crops in these rotations may provide a significant national contribution to biodiesel and aviation biofuel feedstocks.

Growers have traditionally perceived that the advantage of durum–fallow systems in semi-arid environments is to conserve water from incident precipitation during the fallow year that can supplement cropping season rainfall and potentially increase yields of the subsequent crop, which is typically durum. Weeds, including volunteer wheat, are controlled either by tillage or multiple herbicide applications, as needed, to conserve accrued water during the fallow period. However, tillage during fallow has resulted in large decreases in soil organic matter by as much as 50% over several decades, which is not sustainable (Follett and Schimel, 1989; Fenster, 1997). There also is a large potential for soil erosion from wind and water under tilled fallow conditions (Unger et al., 2006a). Tillage also increases evaporation losses due to soil exposure and reduced its water content (Unger et al., 2006b).

The practice of zero tillage fallow systems, often called chemical fallow, substantially improves soil water capture efficiency during fallow periods compared to conventional tillage systems and can reduce erosion losses (Nielsen and Vigil, 2010). Consequently, herbicide use during fallow periods has become the single largest use of pesticides in Montana (Johnson et al., 1997). Additionally, all chemical fallow systems currently rely primarily on glyphosate (N-phosphonomethyl glycine), a chemical with decreasing efficacy because of weeds developing resistance (Heap, 2012).

A major agronomic concern is the limited diversity of dryland crops in the region, which would be increased by the inclusion

Abbreviations: CRP, Conservation Reserve Program; ETH-FL, ethylfluralin-tolerant weeds; HI, harvest index; NGP, Northern Great Plains; PREH, O, preplant soil water content at the 0- to 120-cm depth; POST, postemergence herbicide application; POSTH, O, postharvest soil water content at the 0- to 120-cm depth; PRECIP, precipitation; WUE, water use efficiency for grain production.