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Safflower Management and Adaptation for the High Plains

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INTRODUCTION

Safflower (*Carthamus tinctorius* L., Asteraceae), has been grown for more than 40 years in the High Plains region of Northern Colorado, Eastern Wyoming, and Western Nebraska (Lyon et al. 1991). A processing plant was active in the Sidney, Nebraska area in the late 1950s and early 1960s. At the time it closed, the University of Nebraska conducted a survey with growers and out of more than 100 recorded problems with safflower, the most frequently mentioned were weed control, disease problems (*Alternaria* spp.), and lower yields of subsequent wheat crops. With the changes in safflower varieties to more *Alternaria* resistant types, an increase in available herbicides, and increases in water storage with improved cropping systems, it was felt that safflower might once again play a more significant role in the region. Over the past 10 years, several cooperative studies have been conducted in the region. This is a summary of these studies with combined conclusions and ideas for further research.

CULTIVAR TRIALS (1991–1994)

The first series of trials conducted were on cultivars. They were planted in early May from 1991–1994 in Wyoming and the Nebraska Panhandle following a wheat crop the previous summer. All seed-beds were prepared with conventional tillage for the cultivar trials. Fertilizer was applied based on soil testing and ranged from 70–40–0 plus 20, N–P–K–S to no additional fertilizer. Plots were six, 31 cm rows wide, 5 m long, the center four rows were harvested with a plot combine for yield after trimming the plot length to 3 m. Weeds were controlled with 1.1 kg ai/ha. Soil types included fine-silty, mixed mesic Aridic Argiustolls; fine-silty, mixed mesic Pachic Haplustolls; loamy, mixed (calcareous), mesic, shallow Ustic Torriorthents; and course-loamy, mixed, mesic Aridic Argiustolls.

'Montola 2000' was the most well adapted line for the region. It produced both the greatest seed yield per ha and one of the greatest oil percentages. Other well-adapted lines included 'Morlin', 'Finch', 'Centennial', and 'S-208'. Annual, average trial-yields ranged from a low of 450 kg/ha in 1991 on a shallow soil in Wyoming to 1900 kg/ha on a deeper soil in Cheyenne, County, Nebraska in 1994. The five-year average yield was 1050 kg/ha with oil percentage averaging 41%. For detailed results of cultivar performance see the annual Nebraska Extension Circular EC-107 (Baltensperger et al. 1995). Wide variation in seed color, disease resistance, seed yield, and oil content make appropriate cultivar selection extremely important for production in the region.

FIELD DEMONSTRATION TRIALS (1992–1994)

Field scale demonstration trials were conducted from 1992–1994 on loamy, mixed (calcareous), mesic, shallow Ustic Torriorthents and coarse-loamy, mixed, mesic Torriorthentic Haplustolls with wheat or fallow as the previous crop in a split strip design. Each field was divided into replicated, 1 km by 3 m strips to compare different seeding equipment, seeding rates, and fallow or continuous cropping using the cultivar 'Montola 2000'. Comparisons were made between planters with double-disk and hoe openers with 18 cm and 31 cm row spacings, respectively. Seeding rates of 11, 16.5, and 22 kg/ha (approximately 300,000, 450,000, and 600,000 viable seeds/ha, respectively) were compared using both planters. Treflan at 1.1 kg ai/ha was applied pre-plant all three years with 40 kg/ha N and 20 kg/ha P. Plant populations were taken after emergence by counting the plants in 3 m of row at three locations within each strip. Yield data were collected at harvest by weighing the entire strip. Means separations were conducted with Duncan's following SAS GLM for significant effects.

Yields were not significantly impacted by planter type averaged over years, but there was a significant year × planter-type interaction as the double-disk drill equaled the performance of the hoe drill in 1994, but was significantly lower yielding the other years (Table 1). Stands were reduced 40% by soil covering in plots seeded with the hoe opener in both 1992 and 1993 compared with the double disk, but yields were still greater

Table 1. Safflower seed yield from drill and seeding rate studies with fallow or wheat (continuous cropping) as the preceding crop, grown at the High Plains Ag Lab, Sidney, Nebraska, from 1992–1994.

			Safflower seed yield (kg/ha)						
			Fallow				Continuous		
Drill type	Row space (cm)	Seed rate (kg/ha)	1992	1993	1994	Avg.	1993	1994	Avg.
Disk	18	11	1050c[z]	600b	720b	790c	370d	600c	490d
	18	17	1110bc	690b	750b	850b	490c	710b	600c
	18	22	1340a	600b	930a	960a	370d	950a	660bc
Double disk average			1170	630	800	870	410	750	580
Hoe	31	11	1330a	600b	550c	830bc	490c	500c	500d
	31	17	1330a	910a	690b	980a	690b	730b	710b
	31	22	1200b	1030a	750b	990a	810a	740b	780a
Hoe average			1290	850	660	930	660	660	660

[z]Yields followed with the same letter within a column are not significantly different at p=0.05 1992 continuous plots were abandoned due to stand loss from limited soil moisture at planting.

Table 2. Safflower plant population from drill and seeding rate studies with fallow or wheat (continuous cropping) as the preceding crop, grown at the High Plains Ag Lab, Sidney, Nebraska, from 1992–1994.

			Safflower plant population (plants/ha) ×1000						
			Fallow				Continuous		
Drill type	Row space (cm)	Seed rate (kg/ha)	1992	1993	1994	Avg.	1993	1994	Avg.
Disk	18	11	370bc[z]	360b	330bc	350b	370bc	170c	270bc
	18	17	400b	460a	390b	450ab	400b	200bc	300b
	18	22	500a	460a	500a	490a	500a	270a	390a
Double disk average			420	430	410	420	210	420	320
Hoe	31	11	170d	150c	260c	190d	150e	130d	140d
	31	17	250c	330b	350bc	310c	250d	230b	240c
	31	22	400b	270bc	403b	360b	330c	220b	280bc
Hoe average			270	250	340	240	190	290	220

[z]Plants/ha followed with the same letter within a column are not significantly different at p=0.05.

with the hoe opener (Table 2). Yields were significantly reduced, by planting safflower in a wheat-safflower rotation (continuous-cropping system) compared with a wheat-fallow-safflower rotation (Table 1). Yields were 50% higher with fallow even when not using the 1992 continuous data, which was a complete loss due to soil moisture shortage at planting. In general, yields and plant populations increased with higher seeding rates for a given drill type. However, the double disk drill produced higher populations except in 1992, so the population trend did not go across drill types. Yield increased significantly with an increase in seeding rate from 11 to 17 kg/ha, and there was an increase some years with each rotation with seeding-rate increases from 17 to 22 kg/ha. It appeared that planting with the disk drill (with narrower row spacing) resulted in earlier senescence, on years with limited available moisture in August, compared with the hoe drill.

Table 3. Field rotations at the High Plains Ag Lab, Sidney, Nebraska, including safflower yield and comparison of wheat yields in rotations involving proso, sunflower and no summer crop (fallow) and continuous cropping.

	Safflower yield (kg/ha)			Wheat yield (kg/ha)		
Field history	1995	1996	1997	1997	1998	1999
Fallow-wheat-safflower	750[z]	1000	1100	2150	1960	1710
Fallow-wheat-sunflower	--	--	--	2210	2480	2040
Fallow-wheat-millet	--	--	--	3360	3280	2360
Fallow-wheat	--	--	--	3310	3460	2400

[z]Safflower followed fallow behind proso millet because the previous wheat crop was hailed out and millet was planted as a rescue crop.

Table 4. Effect of spring wheat (SW) and safflower/sunflower (SF) on the following proso millet (PM) and winter wheat (WW) crops in two continuous no-till dryland cropping systems (WW–SW–PM and WW–SF–PM) at Sidney, Nebraska in 1998 and 1999.

	Yield (kg/ha)					
	1998		1999		1998 and 1999	
Crop	SW	SF	SW	SF	SW	SF
			Grain			
Proso millet	2650	2210[*z]	1600	1750	2130	1980
Winter wheat	2990	1830[*]	287	320	--[y]	--
			Residue biomass			
Proso millet	5090	3050[**]	2410	1770	3750	2410[**]
Winter wheat	5060	4690	4180	3450	4620	4070

[z*,**]Significant difference between safflower and spring wheat at the 0.05 and 0.01 probability level respectively.
[y]Data from both years for grain yield not combined due to a significant year × treatment interaction, while the interaction for biomass was not significant so the combined data is presented.

ROTATION TRIALS (1996–1999)

Field rotations including wheat-safflower-fallow, wheat-sunflower-fallow, and wheat-fallow have been conducted at the High Plains Ag Lab for several years. A replicated study was conducted from 1996 to 1999 to better define the impact of safflower on subsequent crops in a continuous cropping system. The study compared a winter wheat-spring wheat-proso rotation with a winter wheat-safflower-proso rotation on a fine-silty, mixed, mesic Pachic Argiustoll soil. Treflan was applied pre-plant at 1.1 kg ai/ha each year along with fertilizer (50 kg/ha N and 20 kg/ha P and 25 kg/ha S).

Wheat following safflower in the wheat-safflower-fallow rotation were similar to wheat yields where corn, *Zea maize*, sunflower, *Helianthus annuus*, or proso millet, *Panicum miliaceum*, were substituted for the safflower. However, during dry periods all summer crops reduced wheat yields relative to a wheat-fallow system, especially sunflower and safflower (2100 kg/ha behind safflower and sunflowers in 1998 vs 3600 kg/ha in the wheat-fallow rotation).

In the replicated study, biomass was reduced in the proso following the safflower by and average of 30%, but grain yield was similar behind both crops (Table 4). Two years later, wheat yields behind safflower were still reduced (Table 4).

DISCUSSION

It appears that safflower has a negative impact on subsequent crops, even if a fallow period is incorporated into the rotation system. Moisture data was taken from these studies and the moisture extraction by safflower is a driving force in these reduced yields. However, the effect of safflower on crops seems to last longer than measurable moisture differences. Safflower may also alter soil microorganism composition in the soil. This could be associated with either a direct effect from the safflower crop or indirectly from changes in soil moisture during a short period of time, that has a longer-term impact on soil microorganisms.

Safflower yields can be expected to be better on deeper (1–2 m of root explorable soil vs less than 1 m), higher water holding capacity soils that have been fallowed prior to growing safflower. Safflower is a good extractor of moisture from the soil, especially at depths below three feet. However, this could be a big limitation in cropping systems in the region as it seems to negatively impact subsequent crops. Limited residue from the safflower crop could potentially lead to depletion of organic matter in soils when safflower is used in conjunction with fallow. It appears that unless price projections for safflower improve relative to other alternative crops, that it is not the best choice for our region. Additional research is needed on the cause of yield reductions in subsequent crops. Additional work is also needed on disease resistance as this was a yield-limiting factor during above normal rainfall years.

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