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Safflower Seed Yield and Oil Content as Affected by Water and N

Richard Engel and Jerald Bergman
Land Resources and Environmental Sciences Dept. and Eastern Agric. Research Center
Montana State University

Safflower is a broadleaf, annual oil seed crop. It is adapted to the semi-arid cereal grain growing areas of eastern Montana that have a relatively low humidity and a long growing season of 120 days (or over 2,200 growing degree days). Seed is used for both birdseed, oil, and foots (residue from oil refining). Safflower is grown as an alternative crop to small grain rotations to combat weeds, diseases and insects. Although considered drought tolerant, production is affected by water stress in eastern Montana. In addition, nitrogen (N) fertility frequently limits safflower yields. This study was undertaken to quantify the effect of available water on safflower yield potential and oil content, and determine its N requirements.

Field experiments were conducted on a Lohmiller silty clay loam (Ustic Torrifluvents) at the Southern Agricultural Research Center near Huntley, Montana in 1989, 1990, and 1991. Soil N levels (0-48 in. depth) from samples collected prior to seeding were 94, 130, and 28 lbs N/a in 1989, 1990, and 1991, respectively. Field experiments were located on sites seeded to barley the previous season. A single irrigation-line, or line-source sprinkler irrigation system, was used to establish a water gradient. The water gradient ranged from dryland (no irrigation) to a high water regime where the crop was under minimum drought stress through the flowering stage. Three cultivars (Finch, Girard, S-541) were planted in late April at a rate of 7 seeds per square foot. Stripped at right angles to the water gradient were fertilizer N levels of 0, 40, 80, 120, and 160 lbs N/a in 1989 and 1990, and fertilizer N levels of 0, 40, 80, and 120 lbs/a in 1991. The combined treatments produced a field site with a wide range of available water and N conditions.

Available water (stored soil water + rain + irrigation) increased safflower yields according to the linear relationships in Figure 1. The relationships demonstrated that approximately 8 to 11 in. of water was needed to produce the first pound of safflower seed. Thereafter, yield increased approximately 205 lbs for each inch increase in available water.

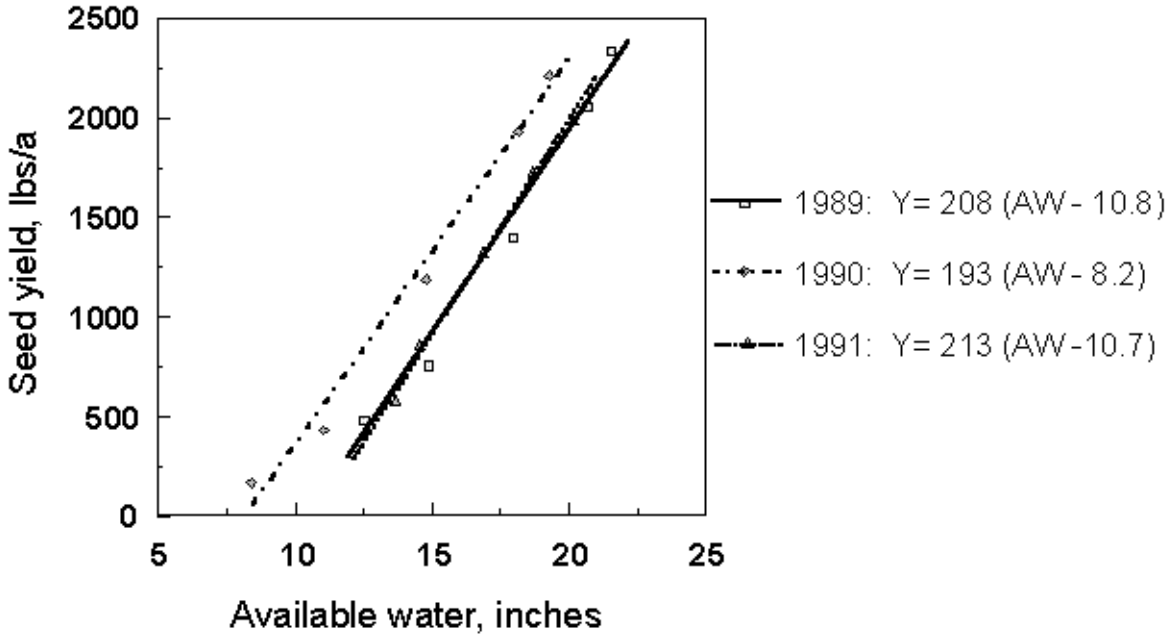

Figure 1. Safflower seed yield as affected by available water.

The relationships were similar for the three cultivars in 1990 and 1991. Girard and S-541 were affected by insect (i.e. thrips) damage in 1989. Hence, only the Finch yield data was considered in developing the yield-water relationship for this season.

Safflower seed yield in 1989 increased approximately 200 lbs/a with N fertilization (40 lbs N/a), but only where available water exceeded 20 in. Seed yields were depressed by N fertilization in 1990 (Table 1). Consistent seed yield increases due to N fertilization occurred only in 1991 with low initial low soil N levels. The yield response to N fertility differed according to available water in 1991. Seed yields were maximized at comparatively low N levels under drought stress conditions. For example, 70 and 90 lbs/a of available N maximized yield at 13.7 and 14.7 in. water, respectively. Thereafter, further increases in N depressed seed yields significantly. As water conditions improved, the response to N increased, producing greater yields and greater N levels (Figure 2).

Table 1. Safflower seed yield averaged across varieties as affected by available N and water (1990).

	Water (inches)				
Available N (FN)†	8.2	11.1	14.8	18.2	19.3
lbs/a	---------- lbs/a ----------				
130 (0)	84	425	1191	1920	2135
170 (40)	100	438	1118	1935	2214
210 (80)	86	365	1060	1777	2038
250 (120)	66	368	893	1604	2020
290 (160)	115	369	961	1602	2021
LSD (.05)	NS	NS	111	145	148
† FN = fertilizer N					

The effect of water on safflower N requirements can be derived from the relationships in Figure 2. Safflower N requirements were defined as the point along the yield-N response curves where economic return was maximized (or optimum) assuming a N cost of $0.25/lb and a safflower seed price of $17/cwt. These optimum N requirements increased approximately 12.5 lb N/a (slope) with each inch of water (Figure 3). Safflower was sensitive to N levels above the optimum. There were several instances where N levels in excess of those required for maximum yield resulted in significant yield losses. This was particularly apparent in 1990 (Table 1).

Nitrogen and water had little effect on seed oil content in 1989 and 1990. Fertilizer N resulted in a slight decrease in oil content in 1991. Cultivar selection affected seed oil content at all water levels during the three years of this study. Results from 1991 indicate that safflower variety can exert a more important effect on oil content than water and N fertility.

Fertilizer Facts

- Approximately 8 to 11 in. of water were needed to produce the first pound of safflower seed. Thereafter, seed yield increased approximately 205 lbs/a with each additional inch of water.
- Safflower N requirements for maximum return (optimum N levels) were equivalent to 50 lbs/a at 13 in. available water. N requirements increased 12.5 lbs/a with each inch of additional water.
- Nitrogen levels above the optimum frequently depressed seed yields.
- Variety selection exerted a greater effect on safflower seed oil content than water or N.

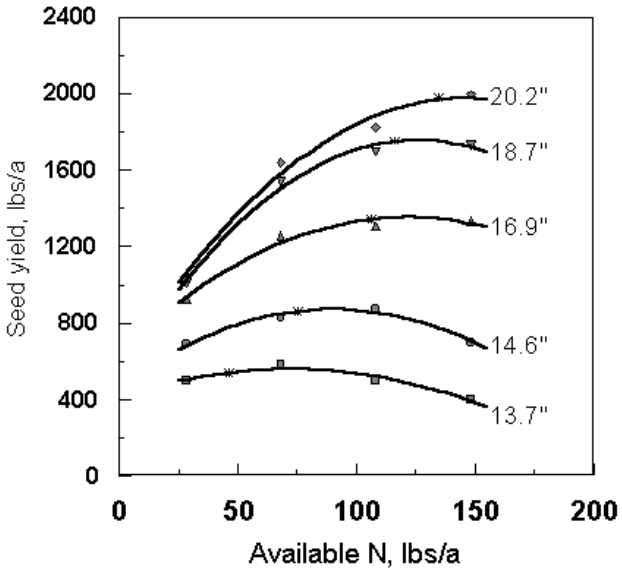

Figure 2. Safflower seed yield averaged across varieties as affected by available N (soil + fertilizer N) and water (1991).

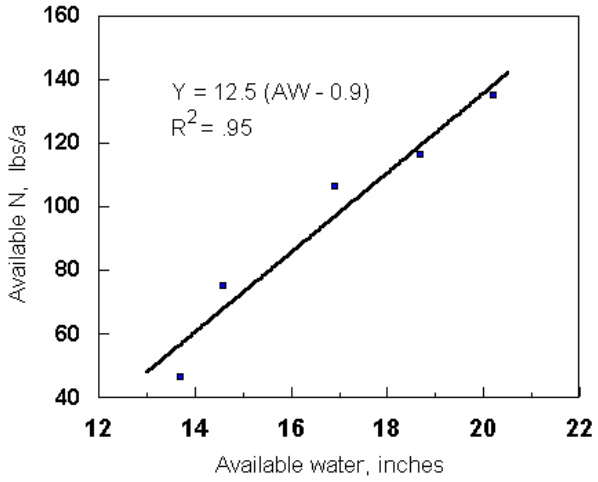

Figure 3. Safflower N requirement for maximum economic yield as affected by available water.

Table 2. Safflower seed oil content averaged across varieties as affected by N and water (1991)

	Water (inches)				
Available N (FN)†	13.7	14.6	16.9	18.7	20.2
lbs/a	---------- % ----------				
28 (0)	42.3	42.5	41.8	41.5	41.6
68 (40)	40.9	41.8	41.7	41.3	41.2
108 (80)	39.6	40.8	41.3	40.8	40.9
148 (120)	39.1	40.4	40.9	40.6	40.5
LSD (.05)	0.5	0.5	0.4	0.4	0.3
Cultivar					
Finch	36.3	37.8	39.1	38.8	38.9
Girard	41.1	41.5	40.8	40.5	40.4
S-541	44.0	44.8	44.5	43.9	43.8
LSD (.10)	0.7	0.8	0.6	0.4	0.6
† FN = fertilizer N					

Edited by Jeff Jacobsen, Extension Soil Scientist