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Response of Oat to Water and Nitrogen

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Nitrogen (N) is the most common nutrient that limits oat production in Montana. Deficiency symptoms are frequently characterized by general chlorosis (yellowing) of leaves and a reduction in overall plant vigor and growth. Oat N deficiency symptoms, as with other cereal grains, will most often appear in the early to late spring depending on severity. Once present, symptoms become more severe through vegetative growth stages. At flowering, N deficient plants are stunted and have fewer tillers and smaller heads than healthy plants. Grain yield is reduced primarily through a reduction in kernels per head and head density.

Nitrogen typically represents a grower's largest fertilizer input cost. Current fertilizer N recommendations in Montana are based on an average relationship between N requirement (NR) and estimated yield potential [Yield potential (bu/a) x 1.1 = NR (lbs/a)] (Table 1). The recommendation assumes 1.1 lbs N/a are needed to produce each bushel of grain. However, this relation may vary with growing season and the yield potential at an individual site. Since yield potential is most closely associated with available water (stored soil water + growing season precipitation), we were interested in determining the effects of available water supply on the N requirement and oat yield potential.

Field experiments were conducted on a Lohmiller silty clay loam (Ustic Torrifluvents) at the Southern Agricultural Research Center near Huntley during 1993 and 1994. Initial soil N levels (0-36 in. depth) were 15 and 22 lbs/a in 1993 and 1994. Field experiments were previously seeded to barley. A line-source sprinkler irrigation system was used to establish a water gradient in the field. Monida oats were planted in early April at 18 seeds per square foot. Stripped at right angles to the water gradient were six fertilizer N levels (0, 20, 40, 80, 120, 160 lbs N/a). The combined treatments produced a field site with a wide range of available water and N conditions.

Table 1. Predicted N requirements for oats with growing season water.

Growing season water	Yield potential	Available N requirement	N:yield ratio
inches	bu/a	lbs N/a	lbs/bu
8	40	60	1.49
10	69	76	1.11
12	97	92	0.95
14	126	108	0.86
16	154	124	0.81

As expected, available water increased oat yield potential and the response to N. Under high water stress, the response to N was small and yield potential was low, producing a comparatively flat curve. As water conditions improved, the response to N increased, producing a steeper curve that reached a higher plateau (Figure 1). Yield potential at the plateau levels, or where N was no longer limiting yields, were similar for the two growing seasons. However, oat yields without N fertilizer were higher in 1994 than 1993. This difference may have been a result of greater N mineralization from organic matter in 1994, resulting in less N deficiency where no fertilizer N was applied.

Maximum economic yield (MEY) was defined as the point along the yield-N curves (Figure 1) where increases in N no longer paid for themselves through higher yield (< 1 bushel increase in yield resulted from 4 lbs additional N), or where dollars returned from N was maximized. Maximum economic yields were generally within 2% of the theoretical maximum, hence they provide a good estimate of yield potential. The MEY-available water relationships (Figure 2) indicate that yield potential increased linearly with water in both 1993 and 1994. The relationships indicate that it takes approximately 4 to 5 in. of water to produce the first bushel of oat, and thereafter yield increases 12 to 14 bu/a with each inch of additional water.

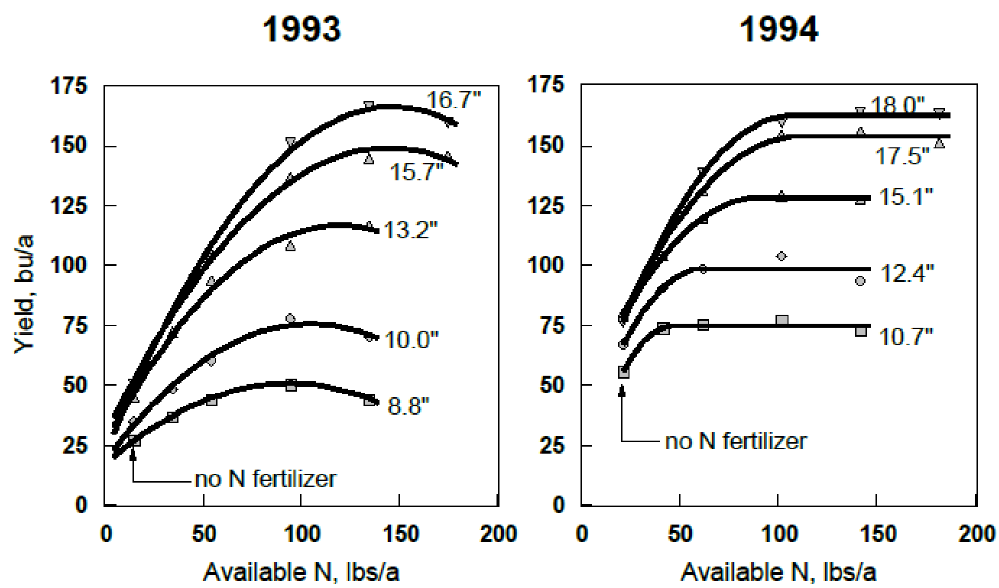

Figure 1. Oat yield in response to increasing available N with different amounts of available water.

Available N requirements (soil N + fertilizer N) for MEY increased linearly with water for both growing seasons (Figure 3). The slopes of the lines for the two seasons were similar and indicate that N requirements increased approximately 8 lbs N with each inch of additional water. However, the intercepts for the lines differ for the two seasons. As a result, it took approximately 35 to 40 lbs/a less N in 1994 to achieve MEY than in 1993 at similar water

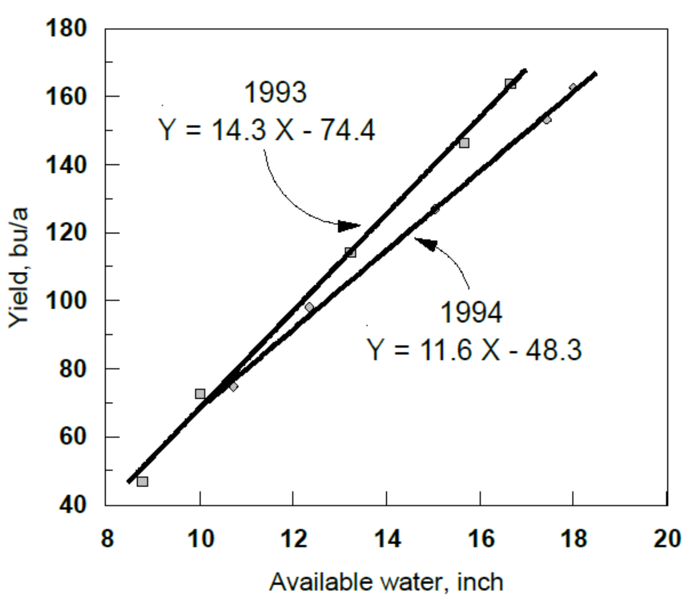

Figure 2. Maximum economic yield increases linearly with increasing available water.

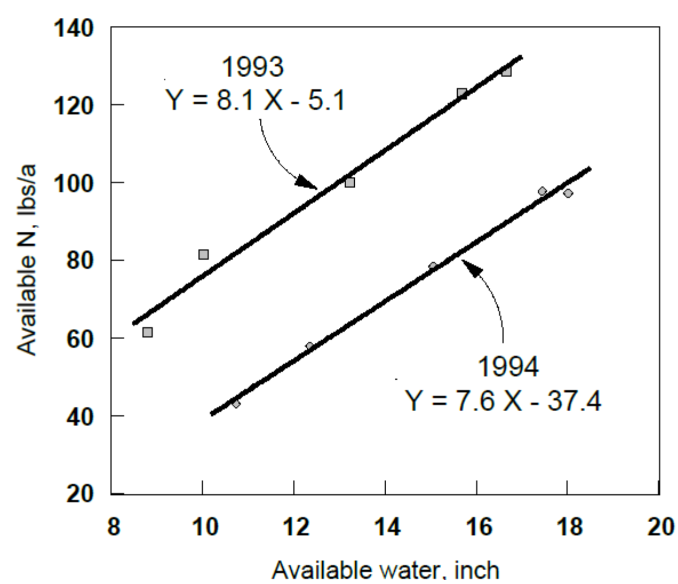

Figure 3. Available N necessary to produce maximum economic yield increases with increasing water, but varies by year.

levels. Background soil N analysis levels for the two seasons were similar. However, barley residue from the preceding crop was burned prior to seeding the 1994 oat crop. This likely enhanced organic N mineralization and resulted in the lower calculated N requirement. Typically, most cereal growers do not burn their residue, hence under most situations the upper line in Figure 3 is probably the better predictor of fertilizer N needs. Using this approach, sufficient fertilizer N should be applied to achieve 60 lbs available N/a where 8 inches of available water (soil water + rainfall) is expected during the growing season. If water conditions improve, N application is increased approximately 8 lbs/a per inch increase in available water.

Fertilizer Facts

- Oat yield potential and N requirements increased with available water.
- Approximately 4 to 5 in. of water were needed to produce the first bushel of oat. Thereafter, yield potential increased 12 to 14 bu/a per inch increase in water.
- Nitrogen requirements for maximum return increase 8 lbs/a per inch increase in water.

Edited by Jeff Jacobsen, Extension Soil Scientist