# Effects of nitrogen fertilization on spotted knapweed and competing vegetation in western Montana

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**Abstract**

**The effects of N fertilization on spotted knapweed (*Centaurea maculosa* Lamarck) and competing vegetation were studied at 2 sites in western Montana during 1981 through 1984. The N was applied 1 time at each site at rates of 56, 112, 224, and 448 kg/ha. Spotted knapweed biomass showed a significant, positive yield response to N at all rates at both sites during the year of application. The only response by spotted knapweed to N in succeeding years was in the second year at Site 1 where a significant response was detected at the 448 kg N/ha rate. Competing vegetation at Site 1 (primarily quackgrass, *Agropyron repens* (L.) Beauv.) in the first year showed a significant, positive response to N, while competing vegetation at Site 2 (primarily crested wheatgrass, *Agropyron cristatum* (L.) Gaertn.) did not respond to N in the first year. No response by competing vegetation to N in succeeding years at either site was detected. There was a significant relationship between percent knapweed and N rate at both sites in the year of N application, but not in succeeding years. These results suggest that N fertilization, by itself, as a cultural control approach to knapweed may be impractical, and could contribute toward the increase of knapweed when used in some of the plant communities normally associated with spotted knapweed on rangeland in western Montana.**

**Key Words: *Centaurea maculosa,* crested wheatgrass, quackgrass, *Agropyron cristatum, Agropyron repens,* biomass, yield**

Spotted knapweed (*Centaurea maculosa* Lamarck) is an introduced, perennial plant that has become a serious problem on rangelands of the Pacific Northwest (Maddox 1979). In Montana alone, the weed infests an estimated 800,000 ha (French and Lacey 1983).

The rapid spread of the plant is due largely to the fact that it was introduced without its natural enemies, is generally not utilized as forage, and may have allelopathic effects on other plant species, enabling it to form near-monocultures (Watson and Renney 1974, Maddox 1982, French and Lacey 1983, Kelsey and Locken 1987). In addition to chemical and biological control methods, cultural practices such as cultivation, irrigation, burning, mowing, reseeding, and grazing have been considered as control measures against the plant (Hubbard 1975, Harris and Cranston 1979, Maddox 1982, French and Lacey 1983, Lacey et al. 1986).

Competitive grasses such as crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.) have been reported to slow the spread of knapweed (Harris and Cranston 1979, Berube and Myers 1982). The use of fertilizers to enhance production of plants known to be competitive to spotted knapweed has not been fully evaluated. Myers and Berube (1983) reported that fertilization with $NH_4NO_3$ at 34 kg/ha had no effect on the growth or biomass of either diffuse knapweed (*C. diffusa* Lamarck) or competing grasses. Popova (1960) reported that application of fertilizer enhanced diffuse knapweed growth at the expense of other forage species.

This paper reports the results of nitrogen fertilization on spotted knapweed and competing vegetation at 2 sites in western Montana.

## Materials and Methods

The study was conducted at 2 spotted knapweed-infested sites, 180 m apart, located 8 km south of Stevensville, Mont. The climate is semiarid with cool summers and comparatively mild winters.

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Average annual precipitation is about 33 cm. Soil at Site 1 was a Chamokane silty, clay loam while Site 2 was a Chamokane loamy sand. Both soils are members of the coarse-loamy over sandy or sandy-skeletal, mixed Typic Xerofluvents. Site 1 was dominated by spotted knapweed and quackgrass (*Agropyron repens* (L.) Beauv.) with small numbers of wood bluegrass (*Poa nemoralis* L.), while Site 2 was dominated by spotted knapweed and crested wheatgrass with small numbers of quackgrass and yarrow (*Achillea millefolium* L.).

The experimental design was a randomized complete block with 3 blocks per site. Nitrogen treatments were hand broadcast as $NH_4NO_3$ at rates of 0, 56, 112, 224, and 448 kg N/ha. Plot size was 7.5 × 3 m. Nitrogen was applied in April 1981 at Site 1 and in April 1982 at Site 2. Plots were harvested in early August in 1981, 1982, and 1984 at Site 1 and in 1982 and 1984 at Site 2. Individual plots were sampled by harvesting all plant material at ground level within three, 0.5-$m^2$ quadrats located randomly in each plot. The plant material was sorted into 2 categories (spotted knapweed and competing vegetation), dried, and weighed. Data from the 3 quadrats per plot were averaged to provide a mean weight (g) for each plant category per plot.

Linear regression analyses were used to describe the relationships between N rates and mean spotted knapweed biomass or competing vegetation biomass. Data from the 2 sites were analyzed separately. A second degree polynomial, generated from multiple regression analysis, was used to fit the relationship between N rate and: (1) spotted knapweed biomass at each site during the year of N application; (2) spotted knapweed biomass at Site 1 in the second year; and (3) competing vegetation biomass at Site 1 in the first year. Percent spotted knapweed data (knapweed biomass/total vegetation biomass) from Site 1 were transformed with a $\log_{10}$ function, while percent data from Site 2 were transformed with a semi-$\log_{10}$. Simple linear regression was used to fit the relationship between competing vegetation biomass and N rate at Site 2 in the first year.

## Results

### Spotted Knapweed Biomass

Regression analyses of first-year data showed a significant, positive quadratic relationship between spotted knapweed biomass and N rate at both sites (Fig. 1). At Site 1, every increase of 1 kg N/ha resulted in an increase of 17.6 kg/ha of spotted knapweed biomass up to a maximum N rate of 361 kg N/ha. At Site 2, every increase of 1 kg N/ha resulted in an increase of 15.6 kg/ha of spotted knapweed biomass up to a maximum N rate of 433 kg N/ha.

Regression analyses also showed a significant quadratic relationship between spotted knapweed biomass and N rate in the second year at Site 1 ($R^2 = 0.97$, $P = 0.02$, $Y = 855.6 - 4.4X + 0.02X^2$). However, the knapweed response in the second year was opposite the first-year response in that there was a very small, negative slope at the lower N rates followed by a significant increase at the 448 kg N/ha rate. Spotted knapweed biomass at the 448 kg N/ha rate in the second year at Site 1 was 41% lower than the biomass at that rate in the first year. Slopes of the regression lines for the relationship between N rate and knapweed biomass in the fourth year (1984) at Site 1 and the third year at Site 2 (1984) were not significantly different from zero.

### Competing Vegetation Biomass

Regression analyses of first-year data showed a significant, positive quadratic relationship between competing vegetation (primarily quackgrass) and N rate at Site 1, while at Site 2 there was a non-significant ($P = 0.12$), positive, linear relationship between the competing vegetation (primarily crested wheatgrass) and N rate (Fig. 1). At Site 1, every increase of 1 kg N/ha resulted in an increase of 13.6 kg/ha of competing vegetation biomass up to a maximum N rate of 340 kg N/ha.

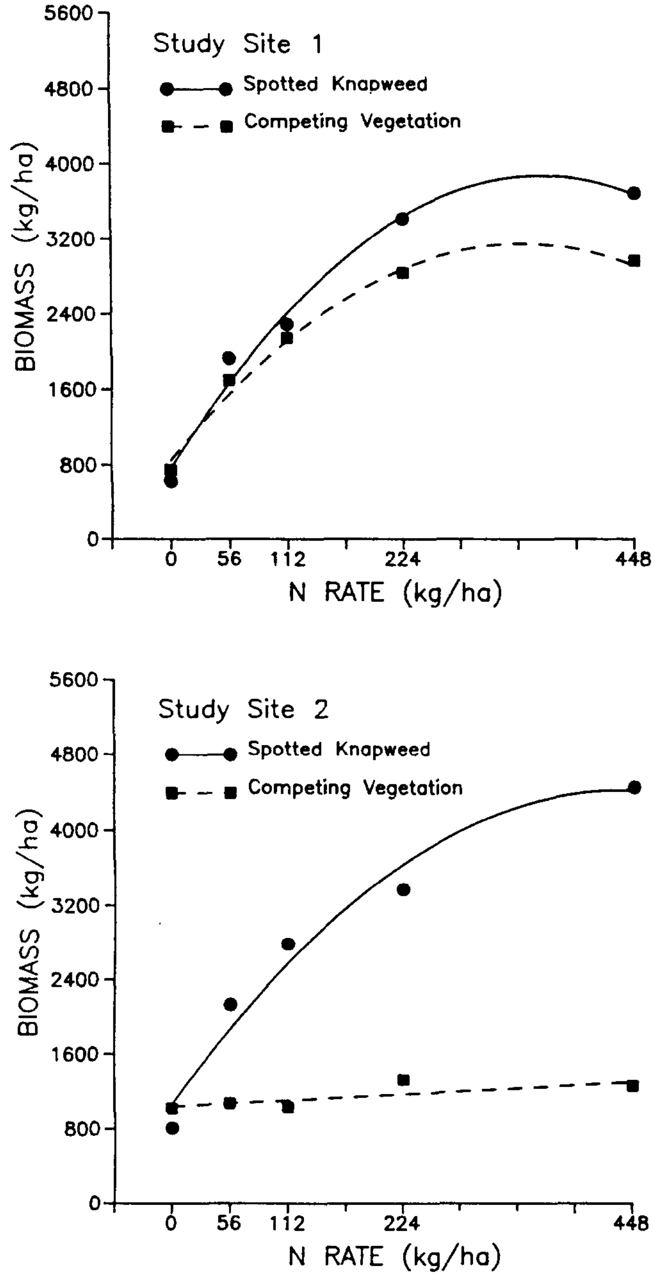


**Fig. 1.** *Relationship between nitrogen rate and biomass of spotted knapweed or competing vegetation at the 2 study sites in the year of nitrogen application. Lines were fitted from the following regressions: spotted knapweed biomass at Site 1: $Y = 760.0 + 17.6X - 0.02X^2$ ($R^2 = 0.98$, $n = 5$, $P = 0.02$); competing vegetation biomass at Site 1: $Y = 845.2 + 13.6X - 0.02X^2$ ($R^2 = 0.99$, $n = 5$, $P = 0.001$); spotted knapweed biomass at Site 2: $Y = 1055.2 + 15.6X - 0.02X^2$ ($R^2 = 0.97$, $n = 5$, $P = 0.03$); competing vegetation biomass at Site 2: $Y = 1035.6 + 0.6X$ ($r^2 = 0.61$, $n = 5$, $P = 0.12$).*

The slopes of the regression lines for the relationship between N rate and competing vegetation biomass in years succeeding the year of N application at the 2 sites were not significantly different from zero, although a weak response ($P = 0.07$) was detected in the second year at Site 1.

### Percent Knapweed

A significant, positive relationship occurred between percent spotted knapweed (knapweed biomass/total vegetation biomass) and N rate at both sites in the first year (Fig. 2). Each site showed a

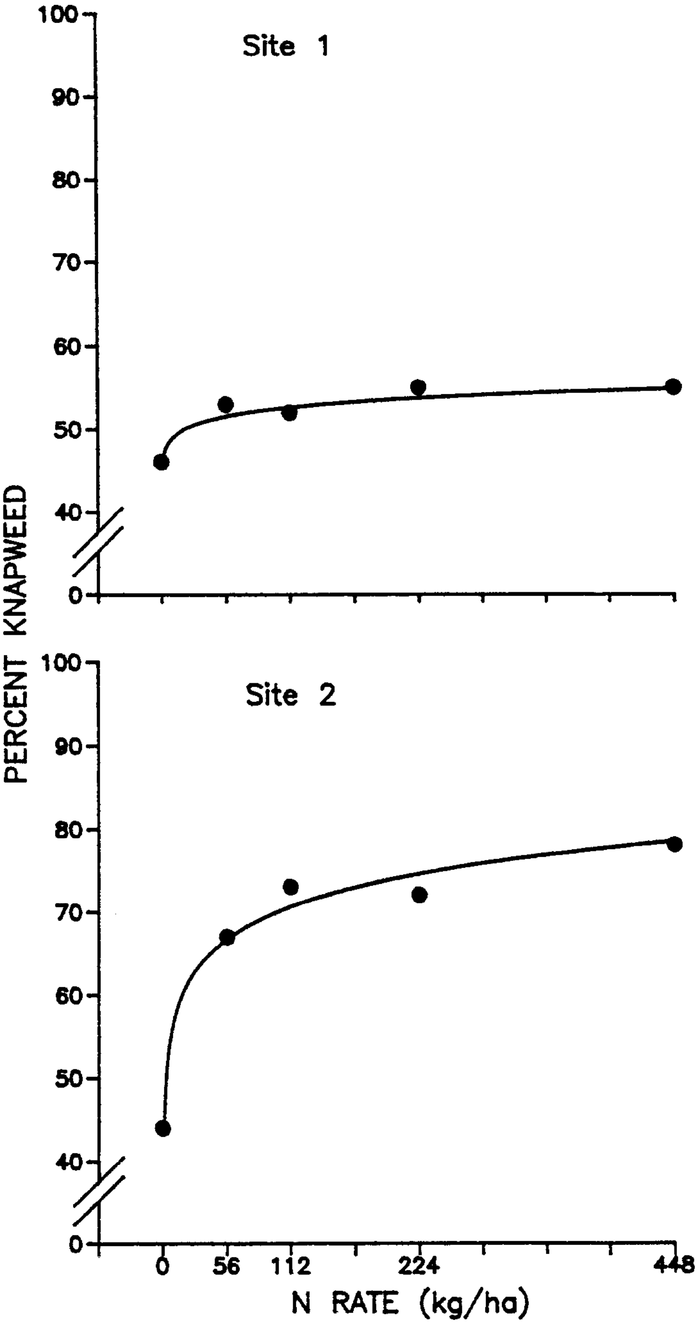


**Fig. 2.** *Relationship between nitrogen rate and percent spotted knapweed biomass (knapweed biomass/total vegetation biomass) at the 2 study sites in the year of nitrogen application. Lines were fitted from the following regressions: Site 1: $\log Y = 1.66 + 0.031 \log X$ ($r^2 = 0.94$, $n = 5$, $P = 0$); Site 2: $Y = 44.0 + 13.01 \log X$ ($r^2 = 0.98$, $n = 5$, $P = 0$).*

strong response at the 56 kg N/ha rate with only small increases at the higher N rates. Slopes of the regression lines for the relationship between N rate and percent knapweed in years succeeding the year of N application at the 2 sites were not significantly different from zero. Mean percent knapweed in treated plots at each site/year was highest in the first year at both sites (52 and 67% at Sites 1 and 2, respectively), but decreased to about 40% in subsequent years.

## Discussion

Our results with spotted knapweed differed from Myers and Berube's (1983) work with diffuse knapweed. They reported that fertilization with $NH_4NO_3$ at 34 kg/ha had no effect on the growth or biomass of either diffuse knapweed or the competing grasses. They suggested that the lack of response by diffuse knapweed in their study was possibly due to selective grazing of fertilized plots by cattle or because fertilizer application occurred too late in the spring. The differing results were probably not due to differences in the 2 plant species' response to N fertilization since Popova (1960) reported that fertilizer enhanced diffuse knapweed growth at the expense of other vegetation.

Reasons why the residual effects of N on both spotted knapweed and competing vegetation were so short-lived were not determined. Leaching may have accounted for some N loss, but the amount of precipitation that fell during October through April following N application at both sites was not excessive (i.e., 22.2 cm and 13.3 cm at Site 1 and 2, respectively). Thus, other nitrogen-loss mechanisms undoubtedly contributed to the short-lived residual.

The weak response of crested wheatgrass at Site 2 in the first year compared to the quackgrass response at Site 1 was surprising since crested wheatgrass is an aggressive, perennial grass (Holechek et al. 1982) and has been shown to be capable of suppressing diffuse knapweed in certain climatic regimes (Berube and Myers 1982). Also, there is considerable evidence that crested wheatgrass growing in semiarid regions readily responds to nitrogen fertilizer (Black 1968, McGinnies 1968, Power and Alessi 1970, Halvorson and Bauer 1984). The weak response may have been due to insufficient moisture since the amount received at Site 2 during the 3 months between N application and harvest in the first year (8.61 cm) was only half the amount received during those months in the first year at Site 1 (16.05 cm). The response of crested wheatgrass to N is highly dependent upon moisture availability in semiarid areas (Smoliak et al. 1967, McGinnies 1968, Power 1983, Read and Winkleman 1982). The poor response, however, could have also been related to deficiencies of other nutrients, soil type, or environmental factors.

Regardless of the reasons for the variable response by the competing vegetation at the 2 sites, the important point is that spotted knapweed showed a strong response to N at all rates at both sites during the first year. These results suggest that N fertilization as a cultural control approach to knapweed may be impractical and could contribute toward the increase of knapweed when used in some of the plant communities normally associated with spotted knapweed on rangeland in western Montana. However, this does not preclude use of N fertilizers with other grasses and forbs that are found to be competitive with knapweed or the use of N fertilizers in combination with herbicides.

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