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Production and nutritional quality of western ragweed seed in response to fertilization

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Abstract

The importance of western ragweed (*Ambrosia psilostachya*) DC.) in the diet of bobwhites (*Colinus virginianus* Merr.) and their high dietary requirement for essential amino acids prompted us to explore the use of disking and fertilization (nitrogen and phosphorus) to improve its nutritional quality on deep, unfertile, sandy-soil rangelands in western Oklahoma. Fertilization (55 kg N ha^{-1}, 56 kg P ha^{-1} as diammonium phosphate) of disk strips did not readily increase seed production of western ragweed. Fertilizer had no detectable effect on nutritional quality of seeds, which contained an average of 13% crude protein and 21% fat. Conflicting results reported on the effect of fertilizer on the quality of plant proteins within the literature could be attributable to differences of climate and soils, growth habits of different plant species, type and rates of fertilizers, and stages of maturity when plants are harvested for analysis.

Key words: *Ambrosia psilostachya*, amino acid, *Colinus virginianus*, fertilization, northern bobwhite, Oklahoma, western ragweed.

Food has been identified as a critical limiting factor for northern bobwhite (*Colinus virginianus* Merr.) populations in western Oklahoma (Tobler 1973). Western ragweed (*Ambrosia psilostachya* DC.) is an important bobwhite food in Oklahoma (Baumgartner et al. 1952). Strip disking to stimulate growth of native forb species such as western ragweed is a common practice used by wildlife managers (Derdeyn 1975, Buckner and Landers 1979, Webb and Guthery 1983). Fertilizers often are used when disking to increase soil nutrients and ultimately increase primary production (Moore 1972, Derdeyn 1975, Dailey 1988). Numerous studies have documented that application of fertilizer to soils can also improve the nutritional quality of forage (Szuts et al. 1988).

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Crude protein levels in some plant species increase with fertilization (Kirkman et al. 1982, Meredith and Gaskins 1984). However, less is known about how fertilizers influence other important nutrients, such as essential amino acids. Results from studies on cultivated plants are equivocal, with fertilization either increasing (Dubetz and Gardiner 1979, 1980), decreasing (Szuts et al. 1988), or not affecting (Meredith and Gaskins 1984) amino acid profiles.

The importance of western ragweed in the diet of bobwhites (Baumgartner et al. 1952, Robel 1969) and their high dietary requirement for essential amino acids (Eggum and Beames 1986) prompted us to explore the use of disking and fertilization to improve its nutritional quality on rangelands in western Oklahoma. Specifically, we examined effects of nitrogen and phosphorus fertilization on production and protein quality of seeds from western ragweed on semiarid, non fertile, deep-sand sites.

Methods

Study Area

Our study was conducted on 3 adjacent ranches in Woods County, Oklahoma, from August 1988 to February 1990. Although the 3 ranches were not selected randomly, they were characteristic of grazed rangelands for this soil type in western Oklahoma. Soils were dune and deep sands dominated by Tivoli fine and loamy fine stand (mixed, thermic Typic Ustipsamments), Likes loamy fine sand (mixed, thermic Typic Ustipsamments), and Pratt loamy fine sand (sandy, mixed, thermic Psammentic Haplustalfs) with 0-8% slopes. Precipitation received during 1989 was 75.4 cm. Vegetation consisted mainly of little bluestem new taxonomy needed *Andropogon [Schizachyruim scoparium* (Michx.) Nash] and sand sagebrush (*Artemisia filifolia* Torr). Western ragweed was the dominant forb on all study sites. A fence to exclude livestock was constructed around each of 7 study sites. Each study site was divided into four 20 x 25 m plots (with a 3-m buffer zone between plots), which were randomly assigned to either winter disking or winter disking plus fertilization (n = 14 plots/treatment). Plots were mowed and disturbed (not plowed) over to a depth of 10 cm with an offset disk on 30 January 1989. Disking did not remove all plant cover and occurred just prior to the rainy season, so wind erosion was not a serious problem. Soil samples were used to establish fertilization rates (Oklahoma State University Soils Testing Lab recommendations for maximum nitrogen-use efficiency), which were applied at a rate of 55 kg N ha^{-1} and 56 kg P ha^{-1} as diammonium phosphate using a hand-held broadcast spreader on 25 February 1989. Application rates of 30-50 kg N ha^{-1} have been shown to improve forage production on Oklahoma rangeland (Gay and Dwyer 1965, Gillen et al. 1987).

Seed Production Estimates

Seed production from western ragweed was estimated using seed traps as described by Peoples (1992). Traps were buried systematically along 3 x 3 grids (9 m apart) within each plot and contents emptied at 4-week intervals from August 1989 to February 1990. Contents of each trap were dried (55° C) until moisture loss ceased, and whole seed was separated manually from hulls (seed coats without endosperm), enumerated, weighed to 0.1 mg, and converted to kg ha^{-1}. Seed hulls were primarily attributed to insect predation. Seed production estimates were calculated using mass of whole seed and hulls without consideration of insect predation. Whole seed and seed hulls from traps were nutritionally analyzed separately.

Nutritional Analysis

It was necessary to composite seed samples collected in traps from plots within treatments prior to nutritional analysis when seed traps yielded <1.0 g dry mass of western ragweed seed (unfertilized whole seed n = 4, fertilized whole seed n = 5, unfertilized seed hull n = 1, fertilized seed hull n = 2). Seeds were dried again by lyophilization to facilitate grinding to a fine powder using a micro-grinding mill. Fat was assessed by ether-extraction for 6 hours in a Soxhlet Apparatus (Grodzinski et al. 1975). Concentration of the total nitrogen pool (%N) was determined by micro-Kjeldahl analysis (Williams 1984) and converted to a crude protein (CP = %N x 6.25).

After fat-extration, seed residues were hydrolyzed in 6N HCL at 110°C for 24 hours. Concentrations of 17 individual amino acids were determined in derivatized (precolumn derivitization using phenylisothiocynate) seed samples using high pressure liquid chromatography (HPLC) (Waters Model 820 system controller and Model 501 pumps). Solvent conditions and gradients used for separation of amino acids were those described by Cohen et al.(1988). Tryptophan is destroyed by acid hydrolysis (Gehrke et al. 1985), and therefore, was not measured. Non-protein nitrogen was assumed to be all nitrogen not incorporated into 1 of the 17 amino acids detected by HPLC (Bell 1963, Synge 1963). Nitrogen concentration of true protein in each sample was determined as the sum of all amino acid nitrogen; non-protein nitrogen was calculated as the difference between total nitrogen (Kjelkahl analysis) and amino acid nitrogen (HPLC analysis). Details concerning nutrient analysis can be found in Peoples (1992).

Statistics

We assessed the influence of fertilizer on production and insect predation of western ragweed seeds using a randomized complete-block design with study site (n=7) as a block effect and treatment (fertilizer, no fertilizer) as a main effect. Nutrient concentrations of seed did not differ among study sites, so the influence of fertilizer on nutritional quality of seeds was assessed using 2-way analysis of variance with seed type (whole seed, hulls only) and fertilizer as main effects. The general linear models (GLM) procedure of SAS (SAS Inst., Inc. 1985) was used and all tests were considered significant at $P<0.05$.

Results and Discussion

Seed production was highly variable within and among study sites and treatments. Overall seed production estimates did not differ (F =

Table 1. Estimated fat, crude protein, non-protein nitrogen, corrected crude protein, essential amino acid, and nonessential amino acid concentrations as percent dry weight of fertilized and unfertilized whole seeds and seed hulls of western ragweed, Woods County, Oklahoma, 1990.

	Whole seed				Seed hull			
	Unfertilized (n = 4)		Fertilized (n = 5)		Unfertilized (n = 1)		Fertilized (n = 2)	
Variable	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
	%-							
Fat	21.23	0.48	21.29	0.27	4.01		3.57	0.42
Crude protein	12.61	0.13	12.89	0.13	4.56		4.97	0.11
Essential amino acids								
Arginine	0.70	0.05	0.74	0.01	0.10		0.12	0.02
Histidine	0.18	0.01	0.18	0.01	0.04		0.04	0.01
Isoleucine	0.37	0.03	0.38	0.01	0.12		0.12	0.02
Leucine	0.57	0.04	0.58	0.01	0.21		0.20	0.02
Lysine	0.38	0.02	0.37	0.02	0.17		0.16	0.03
Methionine (plus cystine)	0.06	0.01	0.06	0.01	0.01		0.01	0.01
Phenylalanine	0.37	0.02	0.39	0.01	0.12		0.12	0.02
Threonine	0.27	0.02	0.28	0.02	0.12		0.12	0.02
Valine	0.39	0.03	0.42	0.01	0.15		0.15	0.02
Glycine	0.44	0.31	0.44	0.01	0.16		0.16	0.02
Nonessential amino acids								
Tyrosine	0.15	0.01	0.18	0.02	0.05		0.05	0.01
Alanine	0.34	0.02	0.36	0.01	0.14		0.14	0.02
Aspartic acid	0.80	0.05	0.84	0.02	0.27		0.27	0.04
Glutamic acid	1.73	0.12	1.73	0.04	0.32		0.35	0.06
Proline	0.45	0.03	0.44	0.02	0.15		0.15	0.02
Serine	0.36	0.02	0.36	0.03	0.15		0.16	0.02
Non-protein N[a]	40.51	1.45	40.31	0.66	45.69		47.10	2.56
Corrected crude protein[b]	6.65	0.42	6.82	0.18	1.93		1.97	0.29

[a]Nitrogen not incorporated into the 17 amino acids detected by high pressure liquid chromatography; expressed as % of total N.
[b]Crude protein concentration corrected for non-protein nitrogen.

1.78; 1,6 df; P=0.230) between fertilized and unfertilized plots (overall $\bar{x}$ = 49.3 kg ha^{-1}, SE = 8.2). Fertilizer did not influence fat concentrations (F = 0.11; 1,8 df; P =0.753) or crude protein (F = 3.42; 1,8 df; P=0.102) in whole seed and seed hulls (Table 1). Overall, concentrations of crude protein in whole seeds averaged 12.8% (SE = 0.13) compared to 4.8% (SE = 0.11) for hulls (F = 1,829; 1,8, df; P<0.001). Amino acid analysis of whole seed and seed hulls showed no change (P>0.05) in either essential or nonessential amino acid concentrations caused by fertilization when expressed as either percent dry mass or relative proportion of the total amino acid pool (g 16 g N^{-1}) (Table 1). Concentrations of all amino acids differed between whole seed and seed hulls (P<0.05). Essential amino acid requirements in the diet of northern bobwhite are not known but have been published for Japanese quail (*Coturnix coturnix* L.). Amino acid levels in western ragweed would not meet published requirements of Japanese quail for growth and reproduction (National Research Council 1984).

Percentage of the total nitrogen pool determined to be non-protein nitrogen was not influenced (F = 0.10; 1,8 df; P=0.759) by fertilizer. Western ragweed contained a large non-protein nitrogen fraction which averaged 40.4% of the total N (SE = 1.1). Non-protein nitrogen constituents are a varied group of compounds in plants and include alkaloids, ammonium salts, nitrogenous glucosides and lipids, amides, purine and pyrimidine compounds, nitrates, urea, a variety of free amino acids, and others with limited nutritional value (Synge 1963). Correcting crude protein values for the non-protein nitrogen fraction yielded an estimate for true protein in whole seeds of 7.6% (SE = 0.2). Concentrations of the non-protein nitrogen fraction in seed hulls ($\bar{x}$ = 46.4%, SE = 2.5) were greater (F = 9.72; 1,8 df; P =0.014 than whole seeds ($\bar{x}$ = 40.4%, SE = 1.0). No difference (P>0.05) in insect predation was observed between treatments; overall, an average of 28.0% (SE = 1.4) of the seed showed evidence of insect predation.

Wildlife managers should carefully consider the use of fertilization of western ragweed in habitat management programs for quail. Such habitat improvement methodologies can be expensive with questionable results. Overall, seed production was highly variable and quality was not improved with the application of N and P fertilizer at low rates on disturbed sandy-soil rangelands in western Oklahoma. it remains possible that fertilizer applications at greater rates may have improved seed production, but probably not quality (Eppendorfer 1977, Meredith and Gaskins 1984), over unfertilized areas. Quantitative seed production estimates obtained on our study sites may not be comparable with other sandy-soil sites, as grazing practices, existing seed base, and climate will influence overall productivity.

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